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AN ANALYSIS OF RANGE PROBLEMS AND RESEARCH NEEDS FOR THE INLAND EMPIRE

by

W. F. Mueggler

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Ogden, Utah

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INTRODUCTION

The importance of the range resource in northern Idaho and northeastern Washington has often been obscured by the overshadowing dominance of timber values. Most of this area is covered by forests, and wood utilization is the major industry. However, forage utilization, despite its lesser role, is an integral part of the economy of the area.

The range resource and its management problems are somewhat different here than in most other parts of the West. There are two reasons for this difference: the dominance of forested livestock grazing lands, and the relatively high value of the big game resource. The former necessitates thorough consideration of multiple land-use values, and the latter requires considerable emphasis upon deer and elk habitat management.

An attempt has been made to analyse the management problems occurring on both livestock and big game range in northern Idaho and northeastern Washington. Literature pertinent to the problems is briefly reviewed, and the type of additional information required to facilitate development of suitable management practices is given. In conclusion, a research program is suggested for the range project of the Inland Empire Research Center.

DESCRIPTION OF AREA

Location

The area served by the Inland Empire Research Center covers the northeastern part of Washington, essentially north of the Snake River and east of the Sanpoil River, and all of Idaho north of the Salmon River. The above area contains a total of 20.45 million acres. Of this, 7.88 million acres are located in the following Washington counties: Ferry, Lincoln, Pend Oreille, Spokane, Stevens, and Whitman. The remaining 12.57 million acres are in the 10 northern counties of Idaho: Benewah, Bonner, Boundary, Clearwater, Idaho, Kootenai, Latah, Lewis, Nezperce, and Shoshone. This area hereafter will be referred to as the "Inland Empire."

Ownership

Almost 50 percent of this total area is in private ownership, while 45 percent is federally owned or managed, and 5 percent is owned by state and county (table 1). In northeastern Washington 72 percent of the land is under private ownership while in northern Idaho only 36 percent is privately owned. This difference in proportion of private ownership in the two states is indicative of the suitability of the land to agriculture. A fairly large portion of the area in northeastern Washington is in the rolling Palouse wheat lands. North Idaho has a much greater portion of forested lands than northeastern Washington and consequently less agricultural activities.

Table 1.--Forest and nonforest land by ownership in Northeast Washington and North Idaho

	Northeast Washington	North Idaho	Total
		Thousand acres	
Federally owned or managed:	1,903	7,350	9,253
Total forest	1,547	6,973	8,520
Nonforest	356	377	733
State and county:	309	757	1,066
Total forest	288	708	996
Nonforest	21	49	70
Private:	5,672	4,460	10,132
Total forest	2,199	2,545	4,744
Nonforest	3,473	1,915	5,388
TOTAL AREA	7,884	12,567	20,451

Physiography

According to Fenneman (1931), the Inland Empire area falls into portions of two major provinces: the Walla Walla Plateau section of the Columbia Plateau province and the Northern Rocky Mountain province. The former includes that part of Washington south of the Spokane River and a small section of Idaho in the Moscow-Lewiston-Grangeville area. This is categorized as a rolling plateau with young incised valleys. The northern part of Washington and most of Idaho lie within the Northern Rocky Mountain province, which is generally described as a deeply dissected mountain upland (in contrast to anticlinal ranges) with intermont basins.

This section of the Columbia Plateau province is formed of Columbia River lavas, inter-basalt lake beds, and unconsolidated loessial silts. The topography ranges from shallow-soiled, channeled scablands to the noted Palouse region typified by rolling hills of deep loessial soil. The general elevation of this portion of the plateau is around 1500 to 2000 feet. The area is drained by the Spokane River and small tributaries of the Snake River.

That portion of the Northern Rocky Mountain province in northeastern Washington is known as the Okanogan-Selkirk Highlands. It consists primarily of the Selkirk Mountains to the east of the Columbia River and the Okanogan Highlands to the west. These mountains are composed of ancient sedimentary and volcanic rocks, more recent resistant granitics, and glacial drift. The continental

glacier (Cordilleran ice sheet) extended over most of this area as far south as Spokane, and some of the valleys are filled with deposits of quanternary alluvium and glacial till. Both valleys and terraces have permeable sandy soils with gravely subsoils. Mountain soils residual on granitic parent material are readily eroded when exposed. These highlands range between 1500 and 7000 feet in elevation. They are drained by the Pend Oreille, Columbia, and Sanpoil Rivers.

Except for a small section of rolling Palouse hills, most of northern Idaho is a continuous mountain formation of the Northern Rocky Mountain province. In the extreme north are found portions of the Selkirk, Purcell, and Cabinet mountains, while farther south are the Coeur d'Alene, Clearwater, and Bitterroot mountains. Metamorphic and sedimentary materials predominate in the northern part of this area, but there are also considerable quantities of recent alluvials. Glaciation occurred throughout the northern areas far south as Coeur d'Alene Lake. Farther south, the Clearwater and Bitterroot mountains originate from dissection of part of the large granitic Idaho batholith. On the western edge of the batholith is found a sizable area of productive soils volcanic in origin. The highest peaks in this mountain mass rise to better than 8,000 feet, but the majority are of much lower elevation. Major rivers draining northern Idaho are as follows: Kootenai, Priest, Pend Oreille, Coeur d'Alene, St. Joe, Clearwater, and Salmon. The latter two flow into the Snake River which skirts the western edge of the batholith.

Climate

The entire area lies within the region of prevailing westerly winds. It is so affected by the ameliorating influence of the Pacific Ocean that the climate is milder than the latitude and altitude would indicate.

Precipitation varies primarily with elevation, thus there is a general increase in precipitation from west to east as the mountains of Idaho are approached. Prairie areas in Washington receive approximately 15 to 25 inches annual precipitation, the highlands of northern Washington receive around 20 to 30 inches, and the mountain areas farther east in Idaho may get 30 to 60 inches of rain and snow. Considerable variation in precipitation exists because of local elevational differences. The summer months are generally fairly dry, but late spring and fall rains are common. Much of the total precipitation in the mountains falls as snow during the wintertime. Local cloudburst storms of high intensity are known to occur during the summer.

Average summer temperatures range from 55° F. to 65° F., with maximum temperatures seldom exceeding 95° F. in the mountains and 100° F. on the prairies. Average winter temperatures range from 15° F. to 25° F. Minimum winter temperatures are seldom less than -35° F. The frost-free growing season is 120 to 160 days in the lowlands, with some local areas having as many as 200 frost-free days. In the mountainous regions the growing season is generally 80 to 120 days.

Vegetation

By far, the greatest part of the Inland Empire consists of forested types (table 1). This forest land, supporting both commercial and noncommercial growth, covers 70 percent of the total land area. Agricultural croplands occupy another 20 percent, and the remaining 10 percent is considered low elevation grasslands. Most of the non-forested area occurs in Washington, which is only 51 percent forest land, whereas north Idaho is 81 percent forest land.

Vegetation of low elevation nonforested areas in the Inland Empire has been classified by Daubenmire (1942) into three separate zones. These zones, consisting largely of bunchgrass associations, are listed from the most xeric to mesic as: (1) Artemisia-Agropyron zone, (2) Agropyron-Poa zone, (3) Festuca-Agropyron zone. The Artemisia-Agropyron zone is characterized under pristine conditions by the dominant species Artemisia tridentata and Agropyron spicatum; secondary species include Festuca idahoensis, Stipa columbiana, Poa secunda, Carex filifolia, Erigeron corymbosus, Balsamorhiza sagittata, Astragalus spaldingii, and Lithospermum ruderale. The Agropyron-Poa zone is dominated chiefly by herbs, such as A. spicatum, P. secunda, F. idahoensis, B. sagittata, L. sericeus, Potentilla blaschkeana, Sieversia ciliata, Geranium viscosissimum, and Hieracium albertinum. The most mesic low elevation zone, Festuca-Agropyron, lacks the distinctive bunchy appearance of the preceding two zones and supports a greater abundance of forbs. Dominant species here are: F. idahoensis,

A. spicatum, Koeleria cristata, B. sagittata, Achillea lanulosa, H. albertinum, P. blaschkeana, L. sericeus, Epilolrium paniculatum, Collinsia parviflora, Symphoricarpos albus, and Rosa spp. Daubenmire separated each of the above zones into various associations as determined by edaphic differences within zones.

At present, the aforementioned low elevation range zones are in various stages of degradation. Much of the foothill grassland has been so badly depleted by overgrazing that little of the original perennial cover remains. Further degradation has been caused by the invasion of highly undesirable exotics.

Nonforested openings of limited extent occur as mountain meadows and high elevation herbaceous slopes and balds. The meadows generally consist of a luxuriant growth of such herbaceous species as Poa pratensis, Agrostis alba, Deschampsia caespitosa, and Carex spp. Vegetation of the high elevation openings is somewhat similar in general character to that of the low elevation Festuca-Agropyron zone; however high elevation openings support an abundance of Carex spp., Calamogrostis rubescens, and other species not found in the lower zone and lack others.

Forested lands in the Inland Empire have been classified into four major climax vegetation zones with each zone composed of one or more associations (Daubenmire, 1952). The most xeric forest belt consists of the Pinus ponderosa zone, which is dominated by this species. Understory vegetation of various associations within this zone is typified respectively by Agropyron spicatum, Purshia tridentata, Symphoricarpos rivularis, and Physocarpos malvaceus.

The Pseudotsuga taxifolia zone is slightly more mesic than the previous zone. In addition to the type tree, this zone has the following fire climax species: Pinus contorta, P. ponderosa, Larix occidentalis, and Populus tremuloides. Understory vegetation is of a shrubby nature often dominated by P. malvaceus, S. rivularis, and Spirea betulifolia. The Thuja plicata-Tsuga heterophylla zone is of special importance in northern Idaho, for it is within this zone that Pinus monticola occurs as a major seral tree. P. contorta and L. occidentalis are also seralsspecies in this zone and form fire climaxes. Abies grandis is commonly found in this zone as well. Climax understory vegetation consists of such species as Pachistima myrsinitïes, Thalictrum occidentale, Galium triflorum, Clintonia uniflora, and Lonicera utahensis. The highest belt of forest consists of the Picea engelmanni-Abies lasiocarpa zone. In addition to these two trees, Pinus albicaulis, Larix lyallii, and Tsuga mertensiana also form part of the climax. Seral trees include P. taxifolia, L. occidentalis, A. grandis, P. contorta, and P. monticola. Major understory species include P. myrsinitïes, Vaccinium membranaceum, Xerophyllum tenax, and Menziesia glabella.

Forest lands of northeastern Washington are largely within the Pinus ponderosa and Pseudotsuga taxifolia zones. Much of the forest land is at present in seral stages dominated by P. contorta and L. occidentalis. North Idaho has extensive areas in seral stages of the Thuja-Tsuga zone, but the other three zones are also well represented. Approximately one-third of northern Idaho is considered

noncommercial in terms of timber production; this land is chiefly valuable for watershed and recreation use.

Enormous areas of forested lands in Idaho and Washington were devastated by fire in the earlier part of this century. The most famous and disasterous burns occurred in 1910 when almost one-fifth of the total forest area in North Idaho was burned. Other extensive fires occurred in 1919, 1926, 1929, 1931, and 1934. Many of these large burned areas have not as yet reverted to forest growth but persist as extensive brush fields. It has been estimated that nearly one million acres of commercial forest land in northern Idaho remain deforested primarily because of double burns.

Roughly 7.2 million acres, or 35 percent of the total land area, receives grazing use by domestic livestock (table 2). The significance of forested lands to the livestock industry is indicated by the fact that 73 percent of the total area grazed is forest range. Thirty-seven percent of the 14.6 million acres of all forested land receives grazing use by domestic livestock. Forest lands are also the principal habitat for large herds of deer and elk, an important resource in this area.

Table 2.--Land area classification by ownership and type in the Inland Empire.

	Total land area	Forest not grazed	Nongrazed farm land	Forest grazed	Non-forest grazed	Total area grazed
			(Thousand Acres)			
Federally owned or managed:						
National forest	8,073	6,412	-	1,063	598	1,661
Indian	741	-	-	646	95	741
Other	439	289	-	110	40	150
Total	9,253	6,701	-	1,819	733	2,552
State and County	1,066	646	-	350	70	420
Private	10,132	1,685	4,218	3,059	1,170	4,229
TOTAL ALL OWNERSHIP	20,451	9,032	4,218	5,228	1,973	7,201

Resources

According to 1950 census figures there are over 438 thousand people living in the Inland Empire area. Northeastern Washington has 295 thousand of these, with 32 percent living in rural areas. The large city of Spokane, hub of the Inland Empire, accounts for the high urban population. Sixty-one percent of northern Idaho's 143 thousand people live in rural areas. Thus, better than 41 percent of the total population are rural dwellers (table 3).

Table 3.--Human population, Northeast Washington and North Idaho, 1950.*

	Urban	Rural	Total
		(thousand)	
Northeast Washington	201	94	295
North Idaho	56	87	143
Total Inland Empire area	257	181	438

* Lemmi, 1955.

Settlement of the area began around 1860. The first enterprise was largely livestock production, but eventually crop production, forest industries, and mining assumed major roles. At present an increasing number of large processing industries are being established, especially in the vicinity of Spokane.

Livestock numbers have varied considerably during the past 30 years. In 1925, the area supported almost 200 thousand sheep and 187 thousand cattle. Although sheep numbers have decreased greatly since 1935 (table 4, figure 1) there has been a large buildup in cattle numbers. In 1954 the area supported almost 70 thousand sheep and 373 thousand cattle. This change from sheep to cattle during the late 1930's and 1940's has been attributed

in a large part to coniferous regrowth and "brushing in" of the large burns that occurred earlier in the century. Estimated evaluation of all livestock in the Inland Empire area is 38 1/4 million dollars. Cattle account for almost 95 percent of this value. (table 5)

An accurate determination of the value of the big game resource is next to impossible to make. An evaluation can be made of actual expenditure per hunter, but no dollar figure can be applied to the many intangible values such as recreational pleasure obtained by those nonhunters who utilize this resource. Wallace (1954), in comparing expenditures for big game with agricultural values, estimated that in the entire state of Washington big game values were equal to 27 percent of all cattle values and equal to 8 percent of all livestock and products. It is reasonable to believe that the relative importance of big game in northeastern Washington is just as great if not greater than in the state as a whole. Because of northern Idaho's large, well known elk and deer herds and generally reduced agricultural activity, the comparative value of big game here is probably much greater than in Washington. It is estimated that over 6 million dollars are spent annually in the Inland Empire area by hunters seeking deer and elk.

In 1955 a total of 17,441 deer were taken by hunters in northeastern Washington. This is high compared to the three previous

Table 4.--Livestock numbers in Northeast Washington and North Idaho, 1925, 1935, 1945, 1950, 1954.*

	1925	1935	1945	1950	1954
CATTLE					
Northeast Washington	109,318	77,760	192,092	172,313	214,239
North Idaho	77,568	61,176	142,439	117,982	158,717
TOTAL	186,886	138,936	334,531	290,295	372,956
SHEEP					
Northeast Washington	41,655	99,251	72,961	46,145	42,108
North Idaho	68,312	86,523	29,290	23,194	27,751
TOTAL	109,967	185,774	102,251	69,339	69,859
TOTAL ANIMAL UNITS: (= 5 sheep) (= 1 cow)	208,879	176,091	354,981	304,163	386,928

* U. S. Census of Agriculture, 1925, '35, '45, '50, '54.

Figure 1. Changes in livestock classes in the Inland Empire from 1925 to 1954.

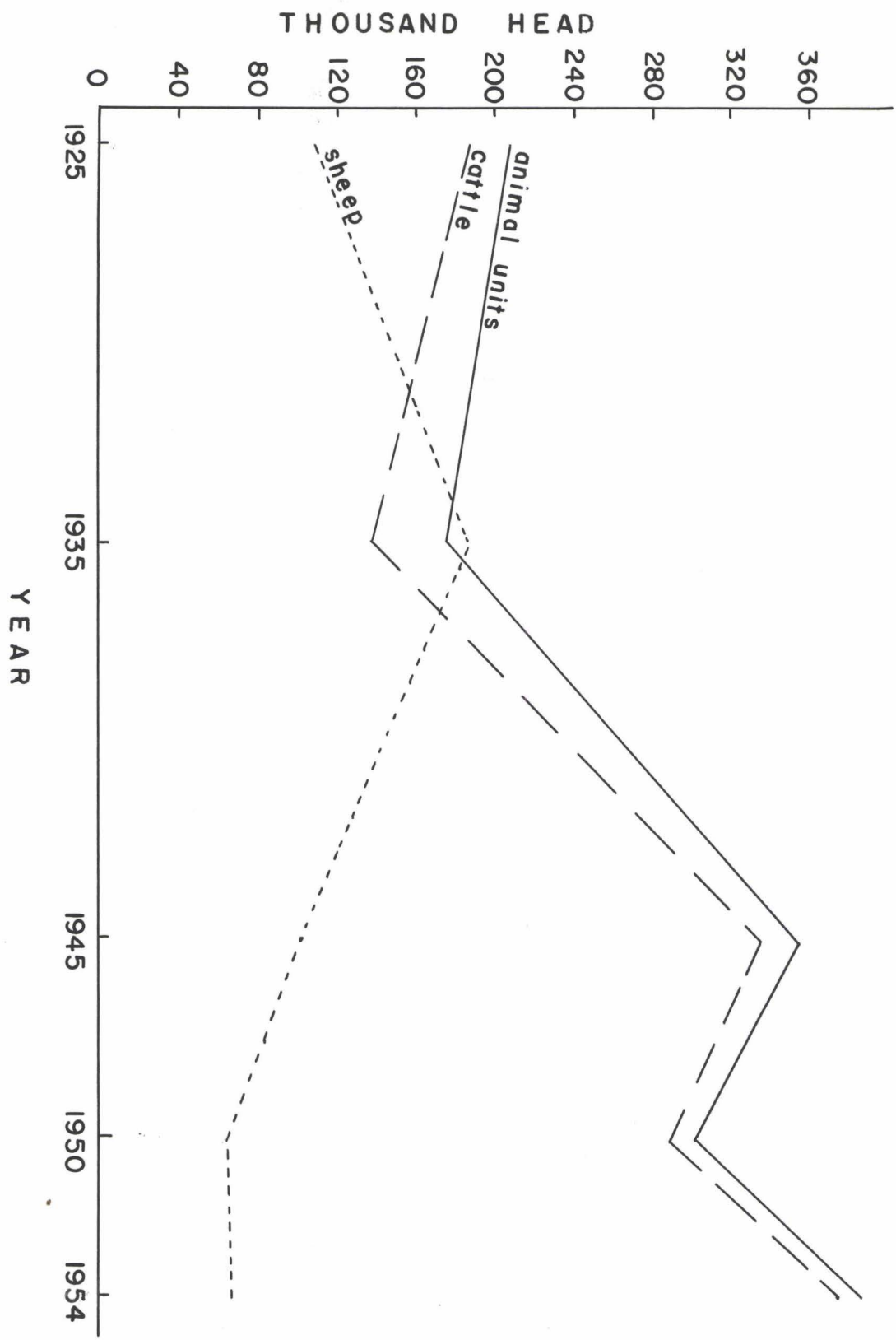

Table 5.--Livestock values (total evaluation) in Northeast Washington and North Idaho in 1954*

	Northeast Washington	North Idaho	Total
		(Thousand Dollars)	
Cattle	20,785	15,397	36,182
Sheep	696	480	1,176
TOTAL CATTLE & SHEEP	21,481	15,877	37,358
Horses & Mules	465	432	897
GRAND TOTAL	21,946	16,309	38,255

* U. S. Census of Agriculture, 1954.

years (table 6), but probably represents a reasonable harvest if critical wintering areas can be maintained. Elk numbers are negligible in this part of Washington. In 1956 a total of 11,800 deer and 8,240 elk were killed in northern Idaho. Animal harvests for the previous years averaged somewhat lower (table 6). Because of lack in accessibility of remote areas in Idaho it is doubtful that elk harvest as a whole is equal to the herd potential. Elk are readily taken in accessible areas but are little touched in areas that can be reached only by pack-string or airplane.

Table 6.--Big game harvest figures for Northeast Washington and North Idaho[1/]

	1952	1953	1954	1955	1956
Deer:					
Northeast Washington	13,769	16,725	14,903	17,441	-
North Idaho	5,752	10,581	13,155	10,600	11,800
Total Inland Empire area	19,521	27,306	18,058	28,041	-
Elk: [2/]					
North Idaho	5,207	7,339	8,669	6,001	8,240

1/ Obtained from correspondence with the State of Washington, Dept. of Game, and the State of Idaho, Fish & Game Dept.

2/ Essentially no elk kill in Northeast Washington.

PROBLEMS

Open Low Elevation Livestock Range

Low elevation bunchgrass-forb areas make up about 25 percent of the grazing land in the Inland Empire. This range is used primarily during the fall-winter-spring period, but some areas receive summer use as well. The type is divided naturally into three geographical locations: the scablands of Lincoln, Spokane and Whitman Counties, Washington, the foothill ranges of Ferry and Stevens Counties, Washington, and the foothill and canyon ranges of Idaho, Nezperce, and Lewis Counties in Idaho. Although some isolated areas are still in fair to good condition (figure 2), the majority have been so abused that they currently support only remnants of the former bunchgrass-forb climax (figure 3). Condition classes run the gamut from very good to depleted, with perhaps the majority falling into the lower half of the scale. Many areas are so depleted that they support little other than inferior annual grasses and forbs. Other depleted areas have been invaded by such undesirable perennials as goatweed (figure 4). Consequently these areas are supporting only a fraction of their potential forage production.

Most of this low elevation bunchgrass range occurs in the foothill and canyon areas of Washington and Idaho. Much of the country has sharp relief, and in some places, such as the slopes of the Snake and Salmon Rivers in Idaho, the topography is almost precipitous (figure 5). Both sheep and cattle use such areas; amount and type

Figure 2a. Good condition low elevation range on Whitebird Hill, Idaho with an abundance of perennial bunchgrass and forbs.

Figure 2b. Close-up of above. Vegetation composed of *Agropyron spicatum*, *Festuca idahoensis*, *Poa secunda*, *Sieversia* sp., *Penstemon* sp., *Achillea lanulosa*, *Eriogonum heracleoides*, and many other forbs and grasses.

Figure 3a. Poor condition low elevation range on Whitebird Hill, Idaho supporting primarily annual grasses and forbs, with reminant perennials.

Figure 3b. Close-up of above. Present composition mostly *Poa secunda*, with an abundance of *Bromus tectorum*, *B. braizeaformis*, *Tragopogon* sp., and *Achillea lanulosa*.

Figure 4a. Bunchgrass range along lower Clearwater River heavily infested with goatweed, apparent in foreground and as dark patches in background.

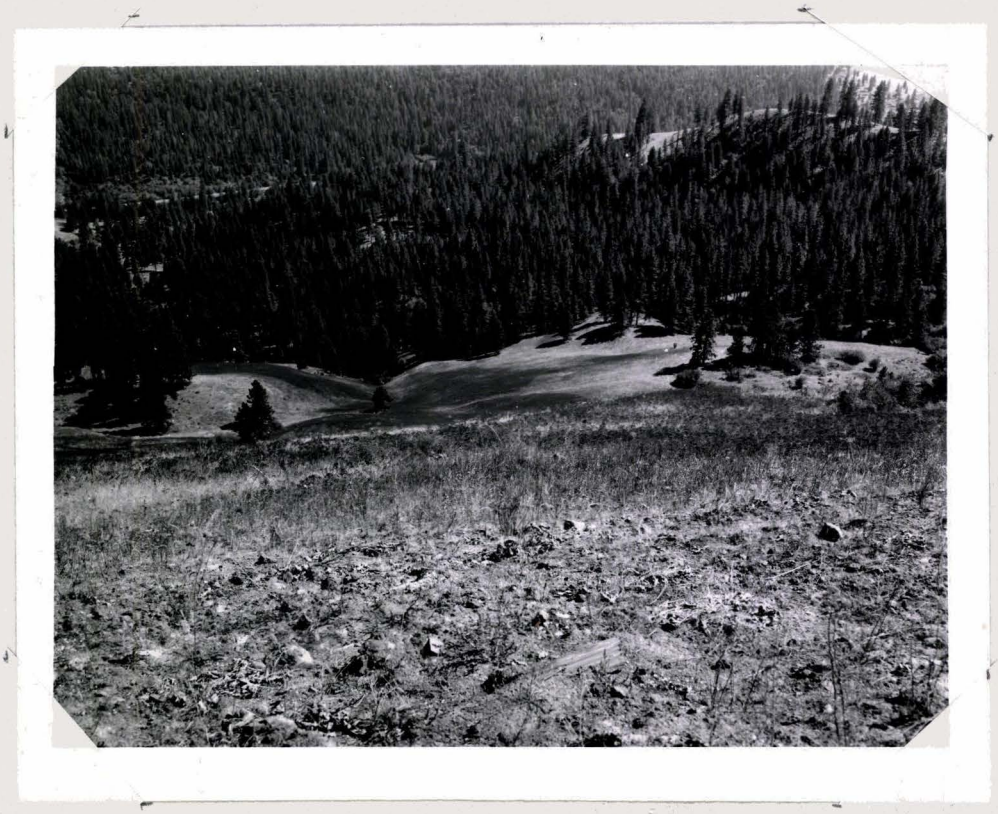

Figure 4b. Goatweed area in vicinity of above that is undergoing control by beetles (Chrysolina hyperici). Beetles have defoliated goatweed in light patches and are moving into dark patches beyond sharp demarkation line of activity.

of use is determined more by proximity to water than degree of slope. Although the soils are remarkably stable with respect to water erosion, because of steepness and season of use they are subject to considerable displacement by trampling. Heavily trailed hillsides are a common sight (figure 6).

Problems concerning low elevation ranges fall into three general groups:

1. Management of nondepleted areas supporting a fair to good cover of moderately desirable and desirable perennials.

2. Restoration of depleted range at present supporting mostly annuals and weedy perennials.

3. Control of undesirable range plants.

Management of nondepleted areas

In order to develop proper management practices for maintenance of forage production under intensive use, it is necessary to have a thorough understanding of the basic ecology of the vegetation concerned. Such information as structure of the vegetal complex under climax and degradations from climax, site potentials, and reaction of plant species and soils to degree and period of use, is essential. With this information, it is possible to establish criteria useful in management. These criteria often take the form of condition classifications, recommended stocking rates by condition classes, and more important yet, sensitive indicators of trend. But in addition certain practical guides and tools must be available to facilitate

Figure 5. An example of very steep low elevation grazing lands along the Salmon River; used primarily in fall-winter-spring period.

Figure 6. Trailing on extremely steep low elevation slopes along the Little Salmon River; fall-winter-spring use.

management. It is necessary to determine the forage level that should be maintained, grazing systems that will maintain that level and still be compatible with ranching needs, and to provide such useful tools as utilization standards.

A good start has already been made in determining the general ecology of bunchgrass vegetation found on these low elevation ranges (Weaver, 1917; Daubenmire, 1942). More specific effects of grazing on vegetation and soils have been described by Daubenmire (1940), Daubenmire and Colwell (1942), and Young (1943). Studies of growth forms of grasses found in this zone have been made in an attempt to facilitate utilization determinations (Ready, 1950; Lommasson and Jensen, 1943). The Soil Conservation Service has published a series of range condition classifications for various conservation districts lying within the bunchgrass zone of eastern Washington (Humphrey, 1946; Marsh and Humphrey, 1946; Spencer, 1947; Gilbert, 1948). And a limited amount of information is available on factors to consider in grazing management practices for bunchgrass vegetation (Anderson, 1952).

Through the above and related work in other areas a foundation has been started upon which to build management practices for this bunchgrass-forb range. However, considerably more research is needed to insure a complete and solid foundation. Such factors as forage potential on various sites, sensitive indicators of range trend, and additional information upon effect of degree and season of use by different classes of livestock should be given primary consideration in future work.

Restoration of depleted areas

Two approaches can be used in restoring depleted range areas: improvement indirectly through management alone, and rehabilitation by a direct method such as artificial seeding. On many low rainfall areas improvement by management alone may involve very long periods of time. The length of time necessary is generally dependent upon amount of desirable vegetation left and type of management practiced. It is conceivable that even under complete closure periods of 15 to 25 years may be necessary to restore badly depleted areas to desirable perennial cover. Where practical, artificial seeding of desirable grasses is a much more rapid method of restoring badly depleted areas. The major drawback here, however, is that much of the depleted range does not lend itself to our present methods of seeding because of rockiness of soil, topography, etc.

In the development of management practices for those areas not adapted to more direct methods of improvement, much the same type of information is needed as discussed above for management of non-depleted areas. However, on areas that now support only annual grasses and forbs with essentially no desirable perennials, serious consideration should be given to management as permanent annual types. To use effectively the direct method of artificial seeding of range areas it is not only necessary to know what species to plant, but when and how they should be planted and what methods are most efficient.

After stands of seeded species are established, we must know how to manage them for the greatest sustained yield.

Considerable effort has been expended in finding species suitable for seeding depleted range lands. Hafenrichter et al. (1949) lists various species for different sites throughout the Pacific Northwest. Friedrich (1947) published a guide for seeding national forest lands in Montana which is directly applicable to many areas in the Inland Empire. Recommendations more specific to northeastern Washington are given by Evanko (1955), based on seeding trials made in this area. In addition to the above, others have provided information useful for artificial seeding in the Inland Empire (Short, 1943; Ensminger et al., 1944; Friedrich, 1945; Schwendiman, 1954).

Through past work species suitable for seeding most depleted low elevation ranges are now available. However, additional effort is needed to develop satisfactory methods and equipment for seeding rocky soils, rough topography, and steep slopes. Moreover, it is necessary to develop grazing management practices for seeded ranges. Very little work has been done on restorative management of depleted areas that are not suitable for artificial seeding. This management phase of rehabilitation must be given consideration if we do not wish to ignore a sizable portion of our range area.

Control of undesirable range plants

Northeastern Washington and northern Idaho appear to be plagued with an overabundance of exotic, undesirable range weeds (Noxious Weed Control Task Force, 1952). At present the most severe and widespread infestation is by goatweed (Hypericum perforatum). It is estimated that well over a half million acres of rangeland in the Inland Empire are infested by this very aggressive perennial. Goatweed is fairly general along the entire eastern edge of Washington and is actively invading other parts. It is distributed in varying intensities throughout northern Idaho, with heaviest infestations on low elevation areas along the Salmon, Snake, and Clearwater Rivers. Fortunately this weed appears susceptible to biological control. Very promising results have been obtained in the southern parts of the Inland Empire area with the goatweed beetle (Chrysolina gemelata and C. hyperici). Races of this beetle or other insects, such as the root borer (Agrilus hyperici), may prove adapted to the more adverse climatic conditions of the northern areas.

Both Dalmatian toadflax (Linaria dalmatica) and diffuse knapweed (Centaurea diffusa) are exceedingly aggressive invaders of depleted ranges in this area. Diffuse knapweed, both biennial and perennial, is primarily a problem of drier areas in Washington,

while Dalmatian toadflax, a perennial, occurs spottedly in Washington and in northern Idaho. Although present infestations of these two weeds are small in extent, they present a severe threat to large range areas. Medusa-head (Elymus caput-medusae), a Mediterranian annual grass, is a worthless species that can dominate badly depleted drier sites in the southern part of the Inland Empire. This range weed does not appear to present nearly the prbblem potential in this area that diffuse knapweed and Dalmatian toadflax do.

The most obvious approach to weed control is that of finding a direct method of killing the offending species. It is preferable to eradicate the undesirable plants without damaging associated vegetation. Extreme methods of cultivation and complete soil sterilization are often used, but these can be applied only on small areas and have the disadvantage of killing all vegetation. Selective herbicides make possible the control of certain species without too much damage to other vegetation and can often be used on fairly extensive areas. So far, goatweed is the only plant pest in the Inland Empire for which biological control methods have been found effective. Weed control through range management practices will, in all probability, be necessary on the majority of

range areas. In order to develop effective management practices for the control of weeds it is necessary to have a thorough understanding of the ecology of not only the weed concerned, but also the vegetal type. Basic information on both the autecology and synecology is a prerequisite.

Most of the range weed research in this area has been concentrated on the control of goatweed. Harris (1951) described the goatweed problem in general as well as various control methods. Pringle (1952) and Tisdale et al. (1953) studied the ecology of goatweed on Idaho ranges and its control by chemical and biological methods. Evanko (1952, 1953) studied the effectiveness of both chemical and biological control in eastern Washington. The phenology of goatweed in relation to behavior of the beetles was worked on by Nelson (1956) in western Montana. A wealth of information on chemical and biological control of goatweed is available from other areas where the same problem exists.

Studies on diffuse knapweed and Dalmatian toadflax have been very limited in extent and restricted to unpublished attempts to determine the effectiveness of various chemical herbicides. A study of the ecology of Medusa-head in Idaho has been made by Sharp and Tisdale (1952), but little information is available on its control.

Future work on goatweed should be directed toward the study of its synecology and especially upon further biological control efforts. Studies should be made to determine proper management practices for goatweed-cleared ranges. Although there is a continued need for work on goatweed, the demand for study of other range weed species is perhaps greater because of the paucity of information available. Dalmatian toadflax and diffuse knapweed especially present a severe threat to rangelands in this area, and as yet very little is known about their ecology or about direct control methods for them. The potential spread of these species should be determined and a concentrated effort made to develop both direct methods of control and control through management practices.

Timbered Livestock Range

Seventy percent of the land within the Inland Empire area is classified as forested. Of this area, approximately 37 percent is grazed by domestic livestock. The importance of this grazing resource to the livestock company is indicated by the fact that over 70 percent of the total grazing lands lie within forested areas.

Forest grazing types can be divided roughly into two major subdivisions: permanent forest range and transitory forest range. Permanent forest range areas are generally restricted to the relatively xeric, open ponderosa pine zone. Such areas are considered primarily spring-fall range but also receive summer use. On these lands utilization of the forage resource can be on a permanent basis because of the open nature of the tree overstory and consequent permanence of the herbaceous understory. This is also true to a certain extent for the Douglas-fir zone. On the other hand, grazing of forest types in the more mesic cedar-hemlock zone can only be considered a temporary use, for the density of the tree cover eventually excludes most of the palatable herbaceous understory. These areas can best be used immediately after logging and up until the young stands begin to close, or for about 10 to 15 years. Grazing occurs here generally during the summer months.

Problems related to grazing forested lands are manyfold, but they are treated below under three major headings:

1. Economic relationship of timber production and grazing.
2. Management of permanent forest range.
3. Management of transitory grazing types in logged mesic forests.

Economic relationship of timber production and grazing

One of the primary needs in the Inland Empire is a workable formula to answer the question of land use. Which areas should be used for the production of forage, which should be used exclusively for the growth of wood products, and where can dual use of forage and timber be obtained. This question of land use involves not only productivity of the site but also related values and local economies. Even though a site is best suited for the production of timber, if the local economy is dependent upon grazing resource, consideration must be given to provide this need at least until changes can be made to reconcile local demands with land potential. Proper land use is a key to the future economy of the Inland Empire.

In order to arrive at a determination of proper land use, certain basic information is essential. It is necessary to know the value of various sites for the production of trees, and the value of such sites in the production of forage. It is also necessary to determine the interrelationship of tree production and forage production upon the same sites and the effect of grazing upon timber production. To properly evaluate the land potential, consideration must be given not only to the present economic structure but to the future demands as well.

Very little has been done directly to satisfactorily solve this problem. It is possible, however, to glean relevant information from numerous published allied studies. A concentrated effort should be made to construct guides for land use. First consideration should be given to areas in the ponderosa pine zone, the permanent forest range type, for here the pressures are great for the production of both forage and wood upon the same land.

Mangement of permanent forest ranges

Permanent forest ranges are of prime importance as a grazing resource in this area (figure 7). Unfortunately, abusive use has so depleted many areas that they fall short of providing maximum forage (figure 8). Such ranges are in relatively dry low elevation zones and are subject to heavy use in the spring prior to forage growth on the higher summer areas, and again in the fall when animals leave the higher ranges. Many of the ranges are grazed in the summer as well. Demands for spring range has continually subjected these low areas to heavy grazing pressure.

The permanent forest grazing types are more or less restricted to the relatively open ponderosa pine zone. This is the lowest and most xerophytic forest type in the area. It generally supports a good herbaceous understory of bunchgrass and forbs. Principal understory species consist of such grasses as Agropyron spicatum, A. inerme, Festuca idahoensis, Poa spp., Stipa colum-

(A)

(B)

Figure 7. Permanent forest range in open ponderosa pine stands with an understory aspect of grasses (A) and shrubs (B).

biana, Calamagrostis rubescens, and Carex spp., and such forbs as Balsamorhiza sagittata, Geranium spp., Potentilla spp., and Achillea lanulosa (figure 7a). Other ponderosa pine stands have a predominant shrub understory composed of such species as Purshia tridentata, Ceanothus volutinus, C. sanguineus, Symphoricarpos rivularis, Physocarpus malvaceus, and Holodiscus discolor (figure 7b).

A few areas in the Douglas-fir zone are considered permanent range types. This is especially true in fairly open stands that support a luxuriant understory of herbs and shrubs.

In order to properly manage permanent forest range areas it is necessary to have a thorough knowledge of the resource. It is not only essential to know the composition and yield of forage on various sites and different ages and densities of the tree overstory, but also to understand how the forage species and soil will react to grazing pressure. This knowledge precedes development of range condition classifications and indicators of trend. The interrelationship of tree and forage growth must be understood, for proper management takes into consideration both of these resources. What is the effect of sheep and cattle grazing upon tree reproduction by species? What is the effect of grazing upon tree growth through soil disturbance and compaction, by changing the competing shrub and herbaceous understory, and the influence of grazing upon fire potential? Likewise, what silvicultural practices, such as thinning, can be used to promote both forage and timber growth? When the above influences are understood it will be possible to begin development of management practices for

this type of range. Comparative grazing values for sheep and for cattle can be determined, as well as stocking rates and grazing systems best suited for dual production of timber and forage.

Special problems of range improvement are involved on these types. On some areas the grazing capacity has been severely reduced by an overabundance of young coniferous reproduction (Harris, 1950) (figure 9). On others hardwood thickets impede livestock use. Methods should be found to open such "brushed-in" ranges to restore usability. Special species and methods are needed for seeding logging roads, skid trails, landings, and other severely disturbed areas. Such seeding should be approached both from the standpoint of forage improvement and erosion control.

Considerable effort has been spent already in studying the vegetation and grazing of low elevation forest zones. A description of the forest vegetation in northeastern Washington and northern Idaho is given by Daubenmire (1952) who divided the ponderosa pine zone into various associations and presented ecologic descriptions of each. The Soil Conservation Service has set up range condition classifications for ponderosa pine-bunchgrass range in several conservations districts (Spencer, 1947, McLaughlin and Sundquist, 1948; McLaughlin and Geiger, 1948). Pickford and Reid (1948) studied forage utilization on summer range

Figure 8. Depleted permanent forest range in an open ponderosa pine stand; understory consists largely of annuals.

Figure 9. Heavy ponderosa pine reproduction on a cut-over stand creating a "brushed-in" situation to the detriment of the grazing resource.

in eastern Oregon, the results of which are applicable to some of the forest range types in the Inland Empire area, while fluctuations of forage utilization on ponderosa pine ranges were described by Harris (1954). An interesting study was made by Rummell (1951) of the effects of livestock grazing on ponderosa pine range in the Meek's Table area of central Washington. Studies not only have been made of logging effects on ponderosa pine rangelands (Garrison and Rummell, 1950), but effects of burning such range have been described (Weaver, 1951). And some practical guides have been established for seeding logging roads and other disturbed areas in the ponderosa pine zone (Gjertson, 1949).

The above work provides a background of information on which to base future study of this permanent forest grazing resource. A more complete understanding should be had of the present and potential grazing capacities of these ranges, as well as effects of grazing upon both forage species and tree growth. Special emphasis should be given to study of the forage-timber relationship, and suitable management practices devised for the benefit of each. Of immediate concern on many areas is the overabundance of coniferous reproduction and shrub growth to the exclusion of forage production; methods should be developed to remedy this situation.

Management of transitory forest ranges

Transitory grazing types in mesic forest areas supply a large part of the demand for summer range. These areas generally lie at higher elevations than the ponderosa pine zone and fall within the Douglas-fir and cedar-hemlock zones. Such dense forest areas provide a grazing resource only when opened by logging or fire (figures 10, 11, 12). These sites are able to produce an abundance of forage growth for about 5 to 15 years prior to closing of the regenerated tree stand (figure 13). Generally these areas are grazed only during the summer months.

Ordinarily such logged and/or burned forest types have an abundance of luxuriant herbaceous and shrub growth. Forbs generally predominate early with shrub production soon assuming a major role. A wide variety of shrubs occurs on these areas, among which are found Ceanothus velutinus, C. sanguineus, Acer glabrum, Alnus sinuata, Pachistima myrsinites, Amelanchier alnifolia, Cornus stolonifera, Holodiscus discolor, Physocarpus malvaceus, Arctostaphylos Uva-ursi, Rubus spp., Symphoricarpos spp., Sorbus spp., Menziesia spp., Vaccinium spp., Salix spp., and many others. Sod-covered roads and skid trails often persist for years and provide a considerable amount of livestock feed.

It is thought there is a much greater potential grazing resource on these logged types than is currently being utilized.

Figure 10. A young-mature white pine stand on the Kaniksu N.F., illustrating closeness of overstory growth and the lack of palatable herbaceous species (dominant herb in foreground is bracken fern).

Figure 11. Clearcut and burned white pine area on the Kaniksu N.F.; such areas are able to produce an abundance of livestock feed prior to regrowth of the timber stand; however down-logs somewhat hamper grazing.

Figure 12. Partial cut white pine stand on the Clearwater N.F. resulting in an abundance of herbaceous growth. Such transitory range might be used for about ten to fifteen years.

Figure 13a. White pine stand on the St. Joe N.F. clearcut in 1915, burned in 1917; photo taken in 1934 after heavy sheep use.

Figure 13b. Same area as 13a. Photo taken in 1944; twenty-seven years after cutting and burning the area is being dominated by trees.

Figure 14. Typical good condition mountain meadow on the St. Joe N.F.

Figure 15. Currently ungrazed meadow on the St. Joe N.F. in good condition; dominant species are Poa, Agrostis, Phleum, and Carex. Apparently heavily used in past as evidenced by remnant Rudbeckia and Circium.

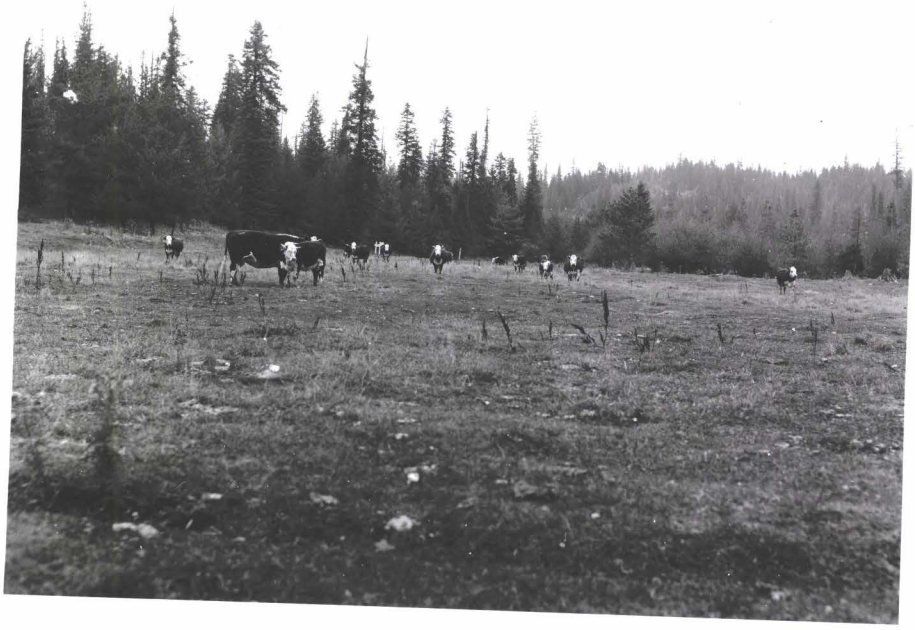

Figure 16. A heavily utilized meadow on the St. Joe N.F. supporting a dense sod of Poa pratensis, Agrostis alba, and Trifolium spp. Fair to poor condition.

Figure 17. Severe gully erosion in a poor condition meadow on the St. Joe N.F.

Figure 18. A seeded meadow on the Colville N.F. supporting an abundance of forage.

Such areas are capable of producing an abundance of feed for a number of years until tree reproduction becomes dominant. With diligent management these areas should not only be able to support a livestock industry, but grazing may actually assist in the establishment of tree reproduction. There is a definite need to determine the feasibility of grazing cut-over timber stands in order to develop this potential grazing resource.

Because of the transitory nature of this grazing type, range depletion itself does not necessitate the consideration it receives on permanent range types. Instead, grazing is secondary to timber production and grazing intensity must be in balance with practices beneficial to tree reproduction and early growth. Therefore grazing management for wood production rather than sustained forage production should be the major consideration. In most cases these management practices will not rapidly deplete the grazing resource.

To evolve management practices for transitory range types it is necessary to know composition, yield, and longevity (persistency) of forage under various timber types and cutting and regeneration practices. Perhaps more important yet, is an understanding of the grazing influences of both sheep and cattle upon reproduction and growth of trees on various types. Grazing influences affecting tree reproduction and stand development

include direct physical damage to desired tree species and indirect influences upon establishment and growth of changes in herbaceous and shrubby competition, soil disturbance and compaction, soil stability, and influences upon fire hazard. In some cases grazing can cause a sodding-over of the ground by bluegrass and clover, which in turn may prevent tree seed from reaching mineral soil as well as strongly compete with established seedlings. Usable management practices must include stocking rates and systems for both sheep and cattle that are compatible with development of the timber stand as well as a determination of silvicultural practices that can be used to promote both forage and tree growth. A substantial amount of forage can be produced by artificially seeding disturbed areas resulting from logging practices. Species and methods of seeding such areas need to be developed both for increased forage production and to promote soil stability. The effect of such herbage seeding practices upon tree reproduction and growth must be determined.

Descriptions of the various forest associations in northern Idaho and northeastern Washington are given by Daubenmire (1952). His work was primarily concerned with climax or near-climax stands, but also some indication is given of seral stages. Work has been done in northern Idaho cut-over white pine areas to determine the influence of sheep grazing on coniferous reproduction and forage (Young et al., 1942). From this 3-year study it was concluded among other things that moderate sheep grazing is beneficial to

white pine reproduction, but that continuous overgrazing is harmful to both coniferous reproduction and the production of more palatable forage plants. A study was made on cut-over Douglas-fir areas in the Cascade Mountains of Oregon and Washington to determine the effect of sheep grazing (Ingram, 1931). Although the forest types are somewhat different, the information derived might have application in this area. It was concluded here that moderate grazing is not inimical to forest regeneration and does have a definite effect in reducing fire hazard. Some indication is given by Lommasson (1947) of longevity of grazing capacity on burned timbered areas of northeast Washington, while both Friedrich (1947) and Evanko (1953) discuss seeding of forage grasses on burned-over timber lands. A grass seeding guide developed by Gjertson (1949) may have some application for revegetating logging roads and skid trails in this area.

Past work has provided encouraging evidence of the compatibility of transitory grazing use with timber production. However a more thorough understanding of the grazing versus timber production relationship is necessary before specific management guides can be established. An exact knowledge of the grazing resource is essential; this should include both productivity for sheep and cattle and longevity of production under various stand ages and densities. Not only is more information required on grazing effects upon tree regeneration and growth but also the effects of various silvicultural practices in promotion of both forage and timber production.

Mountain Meadow Livestock Range

Area-wise, mountain meadows form a relatively small part of the Inland Empire's grazing lands; however, because of their productivity they contribute significantly to the total grazing resource. It is estimated that meadow areas have a grazing capacity 6 to 10 times greater than adjacent forested range. It has been stated that although mountain meadows in eastern Oregon and Washington cover only about 1 to 2 percent of the summer range area, potentially they can produce 20 percent of the summer range forage (Reid and Pickford, 1946). Thus these restricted types fill an important part of summer grazing needs.

Natural grassy meadows are scattered throughout the forested areas of northern Idaho and northeastern Washington (figure 14). Such areas are relatively flat natural openings near the head and along the course of streams and are often surrounded by dense stands of trees. When not depleted by overuse, they support a luxuriant herbaceous growth composed mostly of perennial grasses and sedges, with a scattering of succulent forbs (figure 15). Most prevalent grasses are Poa pratensis, Agrostis alba, Deschampsia caespitosa, Phleum pratense, and others, with a variety of Carex spp. and with Juncus spp., occurring in moist spots. When subject to continual heavy use the soils are somewhat compacted and the meadows take on the characteristics of a lawn, with a dense sod of Poa pratensis, Agrostis alba, and Trifolium spp. generally

predominating (figure 16). With sustained heavy grazing this sod begins to thin and such undesirable perennial forbs as Achillea lanulosa, Taraxacum officinale, Potentilla spp., Rumex spp., Rudbeckia spp., and Circium spp. become more abundant along with an increase of annual forbs on bared patches. It appears that meadows are able to withstand a surprising amount of abuse before erosion becomes apparent, but once gullying starts it is generally of catastrophic proportions (figure 17).

Artificial or induced meadows are sometimes formed along formerly wooded stream bottoms that have been clear-cut, burned, and then heavily grazed. Often the resulting grass-clover sod so dominates these areas that tree reproduction is impeded, and with continued grazing they remain essentially a meadow type.

The problem is primarily one of developing management practices for these lush, highly productive, restricted meadows that are surrounded by large areas of relatively low forage producing timber types containing less palatable species. Not only must practices be determined for maximum forage production on the meadows themselves, but management must consider the integration of these favored meadows with the broader expanse of less favorable timbered range. This latter, however, is primarily an administrative problem; but regardless, it is first of all necessary to know how to manage the meadows themselves.

One of the initial steps in the development of proper management practices for this type is the determination of the potential productivity of the meadows and the vegetal level toward which management should be directed. It is conceivable that greatest forage benefits might be derived here from a vegetal level that is somewhat below the climax type. If this is true, that level needs to be determined. It is then necessary to ascertain the ability of the desired level to withstand grazing pressures and to develop practical condition and trend indicators to guide the range manager in achieving his goal.

On badly depleted meadows methods to speed the restorative process must be determined. This is especially important on areas where soil loss through gullying occurs. Possibilities of artificial renovation and seeding (figure 18) as well as fertilization should be thoroughly studied. In other areas rodents have been responsible for considerable depredation of mountain meadows. It is not thought infestations in the Inland Empire are as severe as in other areas, but still rodent effects are apparent. Actual forage loss through rodent activity should be determined and control methods developed. On very wet meadows largely dominated by relatively unpalatable rushes, the feasibility of artificial drainage should be explored.

Work on the mountain-meadow type has been somewhat limited. However a significant contribution was made by Reid and Pickford (1946) in a study of meadows in eastern Oregon and eastern Wash-

ington. They determined indicators of condition and trend that might have some direct application to northern Idaho meadows as well. Meadow fertilization trials were conducted ineastern Oregon by Cooper and Sawyer (1955), and it was found that substantial increases in vegetal production resulted from applications of nitrogen and phosphorus. Little information is available on meadow seedings in the Inland Empire area, however work in Oregon (Pickford and Jackman, 1944) and in Colorado (Johnson and Hull, 1950) may be applicable to this area. The influence of the Dalles pocket gopher on forage production of meadows in Oregon was studied by Moore and Reid (1951). They found that gopher control allowed a substantial increase of perennial forbs and grasses on meadows in poor condition, but that control may not be necessary on meadows in fair condition. Control methods were discussed in the above publication as well as by Crouch (1942).

One of the most essential factors yet needed for proper management of meadow types is the basic vegetal level toward which management should be directed. What type of vegetation will continually produce the most pounds of beef and still adequately protect the soil? Once this management objective is ascertained, we must have plant and soil indicators to facilitate obtaining and maintaining that level in the meadow types of northern Idaho and northeastern Washington. A survey should be made to determine the necessity of rodent control. Restorative methods of seeding, renovating, fertilizing, and draining should be worked out for depleted meadows and the economic feasibility determined.

Open High-Elevation Livestock Range

Open high-elevation rangeland, or what might also be termed subalpine grassland, furnishes an important part of the summer range forage in the Inland Empire. As in the case of mountain meadows, these high-elevation grassy openings are rather small in total area but highly productive of grasses, sedges, and forbs when in good condition.

There appear to be two different types of open high-elevation ranges in the Inland Empire. In the southern part in Idaho there are fairly extensive grass-forb slopes, especially in the Seven Devils Mountains (figure 19). The openings are more limited in size in the northern part of both Washington and Idaho and consist primarily of small, grassy balds. Although both types are an important grazing resource, they have probably greater value as key watershed areas. These high mountain watersheds are fairly sensitive to abuse, and severe vegetation cover disturbance can result in extreme erosion (figure 20) that markedly affects water yield. Unfortunately, much of the grass-forb type, especially in the souther part of the area, is in various stages of depletion.

Problems concerning high-elevation grazing and watershed lands are classified under two separate headings:

1. Management of fair to good condition range where soil loss is not pronounced.

2. Restoration of depleted and eroding areas.

Management of fair to good condition range

When these subalpine grasslands are in good condition they support an abundance of herbaceous growth and provide excellent ground cover to protect the soil from erosion (figure 21). Vegetation on the open slopes in the southern part of the Inland Empire appears to have a balance of grass and forb species. Here, primary species on good condition range are Carex spp., Festuca idahoensis, Aster spp., Eriogonum spp., Hieracium spp., Lupinus sp., Achillea lanulosa, and others. On good condition grassy balds of the northern areas grasses predominate. Calamagrostis rubescens forms an important constituent along with Festuca idahoensis, Carex spp., Bromus sp., Agropyron spp., and lesser amounts of such forbs as Achillea lanulosa, Penstemon spp., Sieversia sp., Agrostis sp., etc. On slopes with a southerly or westerly exposure, Festuca scabrella often dominates.

Management of high elevation ranges must first consider maintenance of satisfactory watershed condition and second, management at the greatest forage-producing level. Fortunately these two criteria fairly well coincide, for when vegetal cover is sufficient to produce an abundance of forage, it is also generally adequate for soil protection purposes. The difficulty arises when cover

Is not, or barely, sufficient for soil protection and yet still appears ample for grazing purposes. In order to develop management practices for these important areas, a thorough understanding of their ecology is necessary. What is the pristine vegetal composition and how great a divergence from this climax can be allowed before degradation of the grazing resource and soil movement occurs? Once an understanding of the ecology of the type or types is obtained, condition and trend indicators should be determined to facilitate management. An important step in proper management of this resource is to delineate areas that should not be grazed at all because of their critical watershed nature. Such factors as grazing capacities for various types and condition classes, effects of use during different summer periods and by class of stock need to be determined for development of proper management practices.

Work by Pickford and Reid (1942) in northeastern Oregon and southwestern Washington is a valuable contribution to management of subalpine grasslands. Their basis for judging condition and trend may have direct application to high elevation openings in the Inland Empire, especially in the Seven Devils Mountains which are adjacent to their study area. Other than the above, very little work has been done in the Northwest on the ecology of such areas.

The applicability of Pickford and Reid's findings to the high-elevation grasslands of the Inland Empire area should be determined. This material should at least assist in working out the ecology of these types. A thorough understanding of the vegetation on both the grass-forb slopes and grassy balds should be obtained, condition and trend indicators outlined, and management practices developed.

Figure 19. Typical high elevation summer range in the Seven Devils Mts. of Idaho. Essentially an open sedge-grass-forb type with scattered patches of conifers.

Figure 20. Severe gullying that can occur on depleted high elevation summer range (Nut Basin area of Nezperce N.F., Idaho).

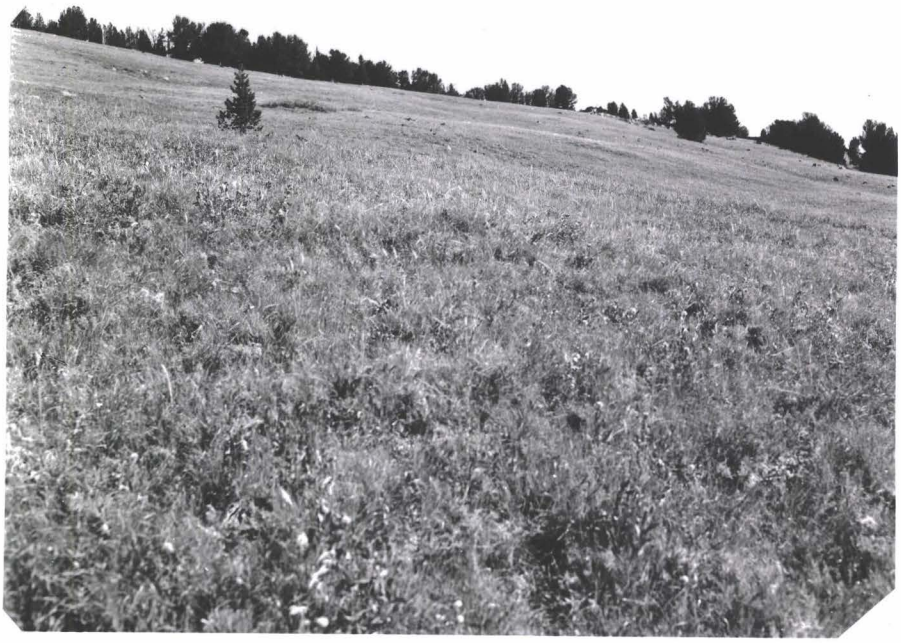

Figure 21a. Good condition high elevation summer range in the Seven Devils Mts., Idaho. Good ground cover and essentially no soil movement.

Figure 21b. Close-up of figure 21a. Vegetation primarily *Carex* spp. with lesser amounts of *Festuca idahoensis*; forbs mostly *Aster*. *Eriogonum*, *Heiracium*, *Achillea*, and *Lupinus*.

Restoration of depleted areas

Because of the great watershed and grazing value of these high-elevation openings, restoration of depleted areas to a stable and productive level is essential. Although it is not known how much of this type is in a depleted condition, the amount appears substantial. On much of the area in poor to fair condition, soil loss is not spectacular (figure 22), but it does occur as evidenced by erosion pavement, pedestaled plants, etc. Once the cover is thinned by overuse, the soil no longer has sufficient protective cover to prevent movement. Not only is the soil not protected, but less desirable forbs begin to replace the heavy sedge-grass cover with corresponding loss in grazing value.

When such areas are badly depleted little protective cover remains and soil loss becomes very rapid (figures 23 and 24). Vegetal cover is often reduced to predominantly undesirable forbs with only remnants of former grasses (figures 23b and 24b). These areas are not only extremely poor watersheds but produce only a small fraction of their original forage. But the most serious result of this depletion is the loss of the basic resource, the soil mantle which has taken hundreds if not thousands of years to form. In all probability it will be necessary to stop grazing entirely on such areas, and even then soil stabilization may not be possible without the use of intensive artificial practices.

Figure 22a. A poor to fair condition high elevation summer range in the Seven Devils Mts., Idaho. Bare soil exposed, soil movement apparent, but as yet no gullies.

Figure 22b. Close-up of figure 22a. Vegetation primarily Carex spp. Festuca idahoensis, Phlox, Lupinus, and Achillea. Notice exposed soil and erosion pavement in contrast to figure 21.

Figure 23a. Depleted high elevation summer range in the Seven Devils Mts., Idaho. Severe gullying on a practically denuded slope; note heavy erosion pavement layer on surface.

Figure 23b. Close-up of badly depleted area adjacent to area in Figure 23a. Severe sheet erosion and resulting erosion pavement. Cover is almost entirely Lupinus.

Figure 24a. Overgrazed and severely eroding high elevation summer range in the Mut Basin area of the Nezperce N.F., Idaho.

Figure 24b. Close-up of figure 24a. Vegetation mostly Aster, Phlox, Achillea, Lupinus, with some Stipa. Notice large bare-soil openings and pedestaled plants.

Because of soil loss, potential productivity of many of these depleted sites has been reduced. This should be recognized in restorative practices. On less badly depleted areas where thin but well distributed cover of desirable perennial species occurs, restoration may be possible through management practices alone. In some cases it may be necessary only to reduce stocking rates or change the summer grazing period to obtain substantial improvement. On other areas closure of the range to grazing for a number of years may suffice to permit a comeback of soil stabilizing cover. However, on badly depleted slopes where soil loss has been great and gullying active, some intensive artificial practices will probably be necessary, such as trenching, gully damming, and seeding of soil-holding perennials. Intensive treatment probably will be necessary only on fairly local areas or "sore spots."

Although little information is available on restoration of subalpine grasslands in the Northwest, findings on similar problems in other areas may be applicable here. Of particular significance is the work of Peterson (1953) in testing forage plants for seeding high-altitude range in Montana. The species he found satisfactory there, common and Parkland smooth brome, meadow foxtail, Kentucky bluegrass, slender and bearded wheatgrass, might also prove adapted to this area. Application of trenching methods used on the Davis County Watershed and similar watersheds in Utah might be satisfactory here.

Using the restorative work in other areas as a guide, methods must be developed for stopping the severe soil loss and vegetal depletion on badly eroding high-elevation ranges in the Inland Empire. Grazing management practices for restoration of less severely deteriorated areas must be devised, and criteria established to delineate usable and nonusable grazing areas from the watershed standpoint.

Big Game Range

Big game animals are a very important wildland resource in the Inland Empire. Northeastern Washington supports a deer herd that is said to produce more animals and afford recreation to more hunters than any other area of equal size in the state. Northern Idaho is more noted for its large elk herds, but it, too, supports a great number of both white-tail and mule deer. It is estimated that between 6 and 10 million dollars are spent annually by hunters in pursuit of deer and elk in this area. In addition there exists the unmeasurable aesthetic value of this resource that is enjoyed by thousands.

The existence of this important resource is dependent upon maintenance of its habitat. Ordinarily big game summer ranges are more than ample to support present numbers (figures 25 and 26), while wintering areas are the limiting factor (figures 27 and 28). Winter ranges are generally restricted to low elevation browse areas of shallow snow. These are commonly found along river canyons, especially in northern Idaho (figure 29). During severe winters deer and elk are forced to concentrate on very restricted areas along the river bottoms and southern exposures at the foot of slopes. These extreme concentration areas are considered critical for the maintenance of the big game herds. During moderate winters the animals are not severely hampered by snow and are able to move rather freely and utilize broad expanses of the low browse range.

Figure 25. Elk summer range of extensive high elevation browse and herbaceous type on the Clearwater N. F., Idaho.

Figure 26. Elk summer range on the Clearwater N. F., Idaho. Browse species Salix spp., Acer glabrum, Alnus sp., with lesser amounts of Sorbus sp., Sambucus sp., and others.

Figure 27. Deer and elk winter range along Lochsa River in northern Idaho. Browse type, formed by old burn, consists mostly of Salix, Alnus, Amelanchier, Prunus, Ceanothus, and some coniferous reproduction.

Figure 28. Deer winter range on Sherman Cr. in northeastern Washington. Browse type a result of old burn, consists of Salix spp., Ceanothus velutinus, C. sanguineus, and others.

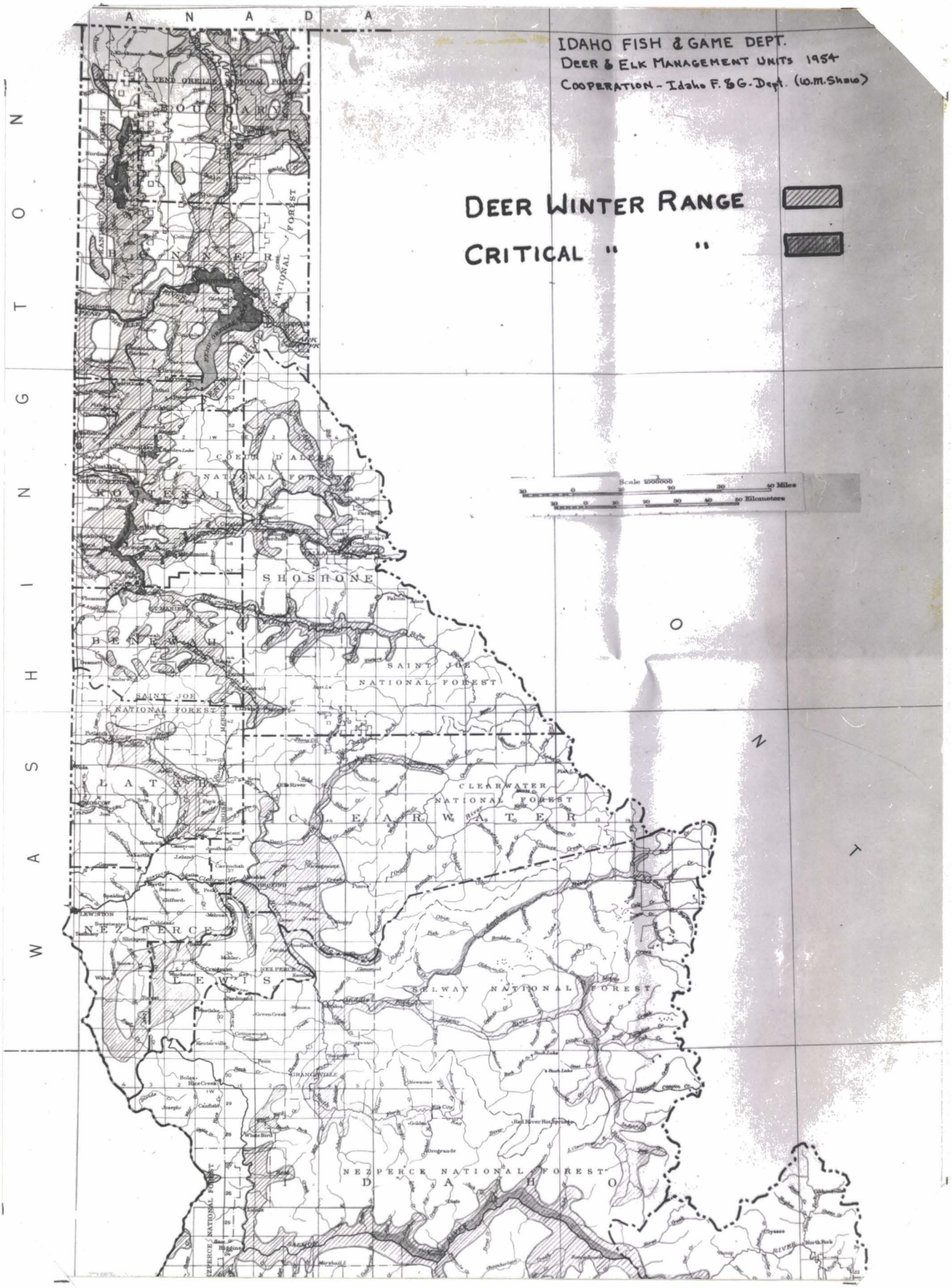

Figure 29. (A). Deer winter range areas in northern Idaho.

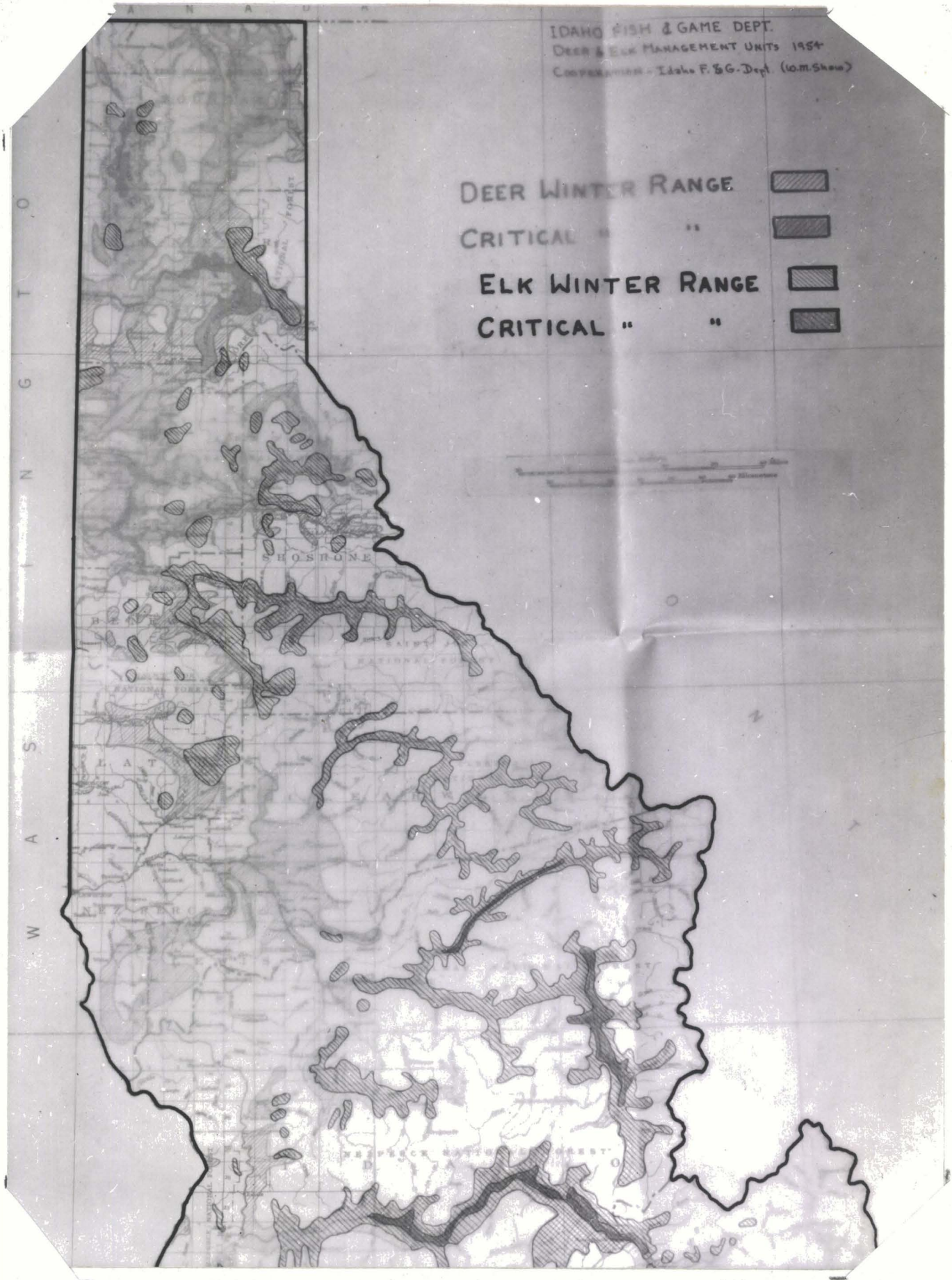

Figure 29. (B). Elk winter range areas in northern Idaho; these are located primarily along the drainages of major streams.

The history of big game animals in the Inland Empire is one of ups and downs. Until about 1890 deer in Washington were severely depleted and considered to be at an all-time low. This was just prior to the establishment of game laws. After the introduction of restrictions, deer gradually beganto increase and during the period 1930 to 1940 increased probably the greatest amount in the history of the state; it has been estimated that deer numbers trebled in Washington during this decade. (Moreland, 1955)

After about 1945 no further increase occurred and it was assumed a stabilization point had been reached. Rather minor fluctuations have been the rule since under more intensive hunting regulations.

The original elk in the Selway drainage of north central Idaho are believed to have crossed over from Montana via the Bitterroot Divide. As late as 1913 elk were rarely seen in this area. However by 1935 the elk population in this one drainage had increased to an estimated 11,000 head, primarily because of the abundant feed and cover in the large browse fields created by the 1910 and 1919 fires. By 1949 numbers in the Selway unit were reduced to about 7,000 head. Elk in the Lochsa and Clearwater drainages are thought to have reached peak numbers in 1946-48 and thereafter began to decline, while in the St. Joe drainage they probably have just recently reached a peak in numbers. (Shaw, 1954)

Deer in the Lochsa drainage of Idaho increased until about 1935 and thereafter began to decline. In 1936 the population in this one unit was estimated at 12,000; by 1949 it was only 2,100. Since about 1940 elk have replaced the deer in much of the upper St. Joe, Clearwater, Lochsa, and Selway drainages. There are few elk north of the St. Joe drainage, consequently deer still reign supreme in the panhandle area of Idaho. In recent years, however, there has been a gradual buildup of the small elk herd in the Coeur d'Alene drainage.

The numerous and extensive forest fires in the early part of the century were largely responsible for the great buildup of deer and elk during the 1930's and early 1940's. These early fires, primarily the 1910, 1919, 1926, 1929, 1931, and 1934 burns, created bounteous big game habitat in the resulting extensive brush fields. As these brush fields gradually revert to coniferous production or attain heights beyond the reach of animals, less and less usable range is available. This combined with reduced fire occurrence and overuse of critical key winter areas has gradually resulted in a general leveling and often decrease in animal numbers. Such decreases in available ranges are limited, for increased logging continually creates new browse fields every year for game use.

In order to maintain the big game resource it is necessary to provide a stable habitat commensurate with the number of animals desired. It is equally important to recognize and place the big game resource in its proper position with respect to other often conflicting wildland resources. The problems of managing this resource and its integration with other land uses are manifold. To facilitate an understanding of the major problems in this area, they are treated under the following headings:

1. Restoration and maintenance of deer and elk winter range.
2. Economic significance of big game to other land uses.
3. Conflict of big game and timber production.
4. Conflict between big game and livestock.
5. Conflict of big game and watershed values.
6. Conflict between different kinds of big game animals.

Restoration and maintenance of big game winter range

Because winter ranges are generally the limiting factor in determining big game numbers in the Inland Empire, they are commonly subject to overuse and in some cases are in depleted condition. Restoration of these critical winter areas and maintenance in a productive condition are essential to stabilization of the big game resource.

Winter range areas in north central Idaho and much of northeast Washington consist of browse types created by forest fires that removed the coniferous stands earlier in the century. Shrub species on such areas include the following: Salix spp., Alnus spp., Amelanchier alnifolia, Acer glabrum, Ceanothus sanguineus, C. velutinus, Prunus emarginata, Sambucus melanocarpa, Cornus stolonifera, Holodiscus discolor, Betula papyrifera, Physocarpus malvaceus, Sorbus scopulina Symphoricarpos albus, Pachistima myrsinites. In extreme northern Idaho, Thuja plicata and Abies grandis are an important part of the winter diet of deer.

Continued heavy use of winter browse ranges has had two different effects. Low growing species, or others if heavily used while still relatively small, are often suppressed by repeated browsing to the snow line (figure 30). Repeated use year after year of parts above the snow profoundly affect normal development of plants (figures 31, 32, 33); however because of the protection afforded lower parts of shrubs by the snow layer many are able to

Figure 30. Rhamnus purshiana (right) and Acer glabrum (left) heavily browsed to snow line by elk on winter range. (Lochsa River, Idaho)

Figure 31. Abies grandis heavily browsed and highlined by elk on winter range. (Lochsa River, Idaho)

Figure 32. Clubby development of Rhamnus purshiana branch resulting from successive winters of heavy elk use. (Lochsa River, Idaho)

Figure 33. Willow stubs 1/2-to 3/4-inches in diameter browsed by elk on winter range. (North Fork Clearwater River, Idaho)

persist in stunted form. Taller growing species, such as Salix spp. and Betula spp. that have managed to extend part of their crowns above the reach of animals, are often severly highlined (figures 34 and 35). These plants continue growth and fully occupy the area but no longer produce available big game feed. In such areas elk will sometimes strip bark from stems in their struggle to survive (figure 36). Loss of winter range is also brought about by coniferous reproduction that tends to crowd out desirable browse species.

Thus, restoration to productiveness of winter ranges in this area involve three fairly distinct problems, the solution of which no doubt will require separate approaches. There is the problem of browse species that have been suppressed and in some extreme cases killed and slopes left essentially barren; this may involve replanting of a few key areas to desirable shrubs. There is the problem of returning to usable production existing browse species that have grown beyond the reach of game animals. A possible solution to this problem is destruction of the tops to stimulate sprouting of certain species (figure 37). And then there is the problem of growth of coniferous reproduction and undesirable species that tend to crowd out valuable browse.

The elk winter range problem on the extensive burns of central Idaho is perplexing. In ordinary winters there is apparently ample feed for all animals. Elk prefer the low-elevation southerly slopes not in the shadow of adjacent mountain masses; these slopes are

Figure 34. Elk winter range on Lochsa River, Idaho. Willow highlined at least 8 feet from ground with bulk of current growth no longer available to animals.

Figure 35. Betula papyrifera highlined by elk on Lochsa River, Idaho, winter range.

Figure 36. Willow stem 5 inches in diameter with bark stripped by elk on winter range. (North Fork Clearwater River, Idaho)

Figure 37. Formerly highlined willow patch restored to usable browse by burning and resulting sprouting of willow clumps. (Lochsa River, Idaho)

no doubt warmer and have less accumulated snow depth on the ground because of comparatively high insolation. If the elk are able to move about somewhat, as in the average winter, these slopes provide sufficient browse to maintain the animals. However during the occasional severe winters (perhaps one or two out of every ten, judging from utilisation evidence) movement of the animals is hampered by deep snow and they are restricted to limited "critical" wintering areas. Here utilization becomes extremely heavy and often many elk die of starvation. Thus the problem is to provide sufficient browse during the occasional severe winters.

The basic problem appears to be one of obtaining a better distribution of animals during the few severe winters. Despite the condition of a "critical" winter range area, if too many animals attempt to winter there it is impossible for the available browse to sustain them. Elk show extreme reluctance to move through deep snow to other areas of available browse. Under these conditions it seems inevitable that animal losses will occur. Some improvement in available browse on critical areas can be obtained to ameliorate this condition, but the problem cannot be solved entirely until either animal numbers are in line with naturally selected critical wintering areas or until some method is developed to obtain a better distribution of animals. The alternative is to accept occasional heavy winter losses as unavoidable and to otherwise manage the herds on the basis of winter range naturally available in average years.

Much basic information on wintering areas is necessary for the development of management practices. Since the majority of wintering areas are on transitory browse types, and understanding of successional stages on various logged and/or burned forest types is required; this includes such information as productivity of successional stages in winter feed for big game and persistency of desirable stages. Specific knowledge should be had of variations in successional stages by differences in climax, site, type of logging, and intensity, season, and size of burn. To ascertain the productivity of an area for game it is necessary to know palatability of the shrub species, and to determine proper use criteria it is necessary to know the response of species to various degrees of use. Once a basic understanding of the various types is obtained it will be possible to develop techniques to restore and maintain productivity of such transitory types.

Past work on ecologic descriptions of the forest types that include big game range were mostly made with the timber resource specifically in mind. Descriptions of such forest types in northern Idaho and northeast Washington are given by Larsen (1930, 1940, Huberman (1935), and Daubenmire (1946, 1952, 1956); in these the browse understory is generally treated incidentally. Pengally (1953) conducted an intensive study of the Coeur d'Alene deer management unit in northern Idaho. Among other things he described browse composition on this restricted area and attempted to show differences in percent available browse by different age

logging sites. Valuable information can be gleaned from the above publications; however an adequate ecologic description of the major big game winter range areas in northern Idaho and northeastern Washington and their successional changes does not exist. An indication has been given of forage values of various shrub species in this area for elk (Young and Robinette, 1939) and for deer (Woolfolk, 1953; Pengally, 1953). Very little information is available on effect of browsing these shrub species. Garrison (1953) made clipping studies of Purshia tridentata, Ceanothus velutinus, Chrysothamnus nauseosus, Holodiscus discolor, and Cercocarpus ledifolius in eastern Oregon and Washington. His findings indicated proper winter utilization varied from about 35 to 60 percent, depending upon species and site.

One of the first steps in future work on big game winter range is to obtain a thorough ecologic description of the areas involved and their stages in succession to the forest climax. Additional information is needed on grazing values of shrub species and response to use. And, of course, direct methods of management must be developed to restore and maintain key winter range areas in a productive browse state.

Economic relationship of big game to other land uses

A major problem in the Inland Empire is the determination of the role of big game in overall wildland management. Big game is recognized as a valuable resource but its value is generally more obscure than competing uses and consequently often underestimated. A true evaluation of our big game resource is necessary so that it can be given its proper place in resource management.

Not only must the value of the animals themselves be known but also comparative value of the land in production of various resources if we are to obtain most wise land use. There are critical game ranges, primarily wintering areas, that probably should be used solely for production of game with all other uses relegated to a secondary position. Other areas are no doubt more important for livestock production, growth of wood products, or watershed, and on these big game production should be a minor consideration. The delineation of these areas into their proper use function is a problem embracing all phases of wildland management. It is necessary to develop criteria which can be used as a guide in selecting areas where big game should be considered the primary use, where game should be a secondary use, and where game should be reduced to a minimum.

Attempts have been made to evaluate big game in Washington and Idaho (Wallace, 1952; Royall, 1954), but an accurate and useful determination is very difficult to obtain because of the relatively intangible nature of this recreational resource. No one has yet proposed a solution to the problem of designating proper land use.

Conflict between big game and timber production

Although the present conflict between big game and timber production is not an extensive problem it is severe in small areas and is beset by many unknowns. There exist a few areas where deer browsing has been very detrimental to coniferous reproduction; on other areas that support fairly large big game numbers conifers are not appreciably affected. This direct conflict, however, can be a severe problem and because of its potential significance should be studied in all of itsaspects.

On the other hand, encroachment of conifers has severely reduced usable big game range in some areas. Although animals require a certain amount of protective cover that is well supplied by thick stands of trees, an extensive mature conifer stand

generally provides very little browse. A balance between protective cover and browse openings is necessary for maximum big game production.

To better understand the actual and potential conflict that exists between big game and timber management, it is necessary to know the place of conifers in the diet of game animals under spring-summer-fall conditions, under normal winter conditions (normal diet), and under severe winter conditions (starvation diet). When and why do big game animals seriously interfere with desirable conifer production? In all probability conflicts of use are present on certain areas simply because the primary land use has not been designated. It is possible that silvicultural practices might be developed to benefit both timber production and big game habitat. Such practices as selective cutting to improve browse, planting tree patches on large burns to provide cover, and cutting and thinning during critical winters to provide emergency feed should be explored.

Among the few published works related to the big game-timber production conflict in this area are those by Adams (1949, 1951, 1951a) and Neils et al. (1956). They reported the effect of deer on conifer reproduction and on ponderosa pine management in northwestern Montana. It was found that deer preferred ponderosa pine to Douglas-fir seedlings and that heavy use can be detrimental

to the development of the conifer stand; however it was thought that such heavy browsing of conifers occurred because the animals were on a starvation diet.

Further work needs to be done to determine the role of conifers in the diet of game animals in order to ascertain the degree and extent of conflict with timber production. But perhaps more important yet is the development of silvicultural practices that will be mutually beneficial to both timber production and big game habitat.

Conflict between big game and livestock

There is considerable overlap of big game range and livestock range in the Inland Empire because so much of the livestock range is in forested types. With dual use by different types of grazing animals a conflict in forage use can easily arise. If such a conflict does exist in this area, it is not thought great, as the effects are not apparent. However the possibility of current and potential competition between livestock and big game should be fully explored.

Conflict between big game and watersheds

Heavy concentrations of big game can cause considerable damage to watershed values on steep erodible slopes. Although deer and elk contribute to vegetal denudation their most pronounced effect is by trampling displacement and trailing. Greatest con-

centrations of animals generally occur on winter range areas, and where these are on steep slopes considerable soil movement may result. There are also occasional examples of eroding high elevation summer ranges that are at least partly attributable to elk use.

The extent big game has contributed to watershed depletion has not been determined; it is only known that such depletion does occur. To manage big game populations at a level compatible with watershed values requires knowing the amount of trailing and trampling considered excessive to soil stability. Methods of controlling animal distribution to prevent excessive concentrations would be an extremely valuable management tool not only for watershed protection but for maintenance of the habitat as well.

Conflict between different kinds of big game animals

Considerable concern is often expressed over apparent competition between species of big game animals. This judgment is generally based upon the premise that elk "drive out" deer, and mule deer "drive out" white tail deer. The marked change in relative numbers of different species on some areas over a period of years lends support to this competitive conflict, however, such animal changes are often preceded by changes in vegetal cover determined by fire, natural succession, etc. Much of the change in animal composition that appears to be the effect of animal competition is no doubt caused by habitat changes not directly associated with the animals.

On the other hand, competition becomes real when different species of animals occupy the same area and must subsist on the same food resource. Fortunately, elk, mule deer, and white-tail deer each have slightly different habitat preferences. Direct competition is most likely to occur on restricted winter ranges. As can be seen in figure 29, there is considerable overlap of elk and deer winter range in Idaho.

A game census report on game management units in Idaho by Shaw (1954) is laced with comments associating decline of deer with corresponding increase in elk, suggesting direct competition as one of the main reasons. Pengally (1953) in a study of one management unit in northern Idaho found only small areas where overlapping use of winter range by two or more game species occurred.

The degree and extent of competition between big game species and the resulting effect upon animal occupancy needs to be determined. Methods of environmental manipulation should be devised to maintain deer herds with exclusion or in company of elk, and to favor the desired species of deer.

PRIORITY EVALUATION

A listing of major range problem areas in the Inland Empire with a suggested study priority by areas is given in table 7.

The importance of big game as compared to the domestic livestock resource can be indicated by several measures: acres of land grazed, numbers of animals involved, annual expenditures for each. In the Inland Empire about 35 percent of the total land area is grazed to some extent by livestock compared to an estimated 70 percent of the total land area used by big game animals. Animal populations are indicated by figures for 1954 when there were 373 thousand head of cattle and 70 thousand head of sheep in the area; in the same year there were an estimated 68 thousand elk and 257 thousand deer. The value of livestock sold alive in 1954 (cattle, sheep, wool) was a little over 15 million dollars (U. S. Census, 1954), while the estimated expenditure in 1954 by hunters in pursuit of big game in the Inland Empire was in excess of 6 million dollars (computed from figures given by U.S.D.I. 1955, and Idaho and Washington State Fish and Game Departments). Six million dollars is considered a conservative valuation of the big game resource, for it does not include the many recreational aspects provided by big game animals to non-hunters. Thus the livestock resource is apparently of greater economic importance than big game in the Inland Empire, but the significance of big game to the area is obvious.

Despite the importance of big game to this area, comparatively little has been done to determine suitable methods for management of its habitat. The seral-shrub game habitat in the Inland Empire is unique as a problem type, whereas studies conducted on livestock range throughout the Northwest and northern Rocky Mountain areas can be applied, in many cases, to livestock range in this area. As a result it is thought the need for research on big game ranges is greater than on livestock ranges in the Inland Empire.

As mentioned earlier, winter ranges are the limiting factor in controlling big game numbers in this area; summer ranges appear ample at present. In order to sustain the big game resources, it is essential to maintain winter range areas in productive condition. These winter ranges demand first consideration in overall game habitat management.

Although the bulk of livestock grazing land in the Inland Empire consists of forested range, the most critical livestock range problem occurs on the open high elevation summer ranges. The latter are very limited in area but highly productive of forage when in good condition; of perhaps greater importance yet is their value as watersheds. These high elevation openings are very sensitive to grazing abuse. When the ground cover is disturbed appreciably, the soils often erode rapidly and both the watershed and forage values deteriorate correspondingly. Many areas are at present in a state of active soil loss. The key nature of these areas combined with their sensitivity to grazing abuse and current soil de-

pletion demand that they be given high priority in research effort for development of suitable grazing management and soil stabilization practices.

Forested range areas are not nearly as sensitive to abuse and irreparable damage as are the high elevation openings, consequently the need for management answers is not so urgent. However, because of the dominant place of forest ranges in the grazing resource of the Inland Empire (over 70 percent of the total area grazed) and because here livestock use must be integrated not only with watersheds but with timber and wildlife production, they should rank high in priority of study. Work on permanent forest range should take precedence over transitory forest range, for the former consists of areas that are continually being used as grazing lands and must be maintained in satisfactory forage condition. Transitory ranges are a resource that can be used only temporarily by livestock for a few years following timber harvest. The problem of transitory range is largely that of developing a shifting grazing resource compatible with timber production on areas where the primary function is growing trees.

Mountain meadows are ranked fairly low in prisrity. Although such meadows are an important source of summer grazing, most are fairly productive even when in an overgrazed condition and apparently do not erode until severely depleted. They are able to withstand considerable abuse. Research problems of meadow management are not considered urgent, and the land areas involved are relatively small.

The open low elevation livestock ranges are included in the lower priority classifications. These areas involve less than 25 percent of the total grazing lands and receive use during late fall, winter, and early spring. Their only use, aside from minor watershed values, is that of livestock grazing. A very great part of this range is in depleted vegetal condition, but soil erosion is not a major problem. Of greatest need is increased forage production on depleted areas and perhaps this might be accomplished best by artificial revegetation or very conservative use. It is thought that the Agricultural Research Service and the State College of Washington plan to study these low elevation types. In addition, studies conducted in other areas on management of bunchgrass range may have direct application in the Inland Empire.

Table 7.--Priority of major range problem areas in the Inland Empire and type of studies needed, by priority, in each area.

Types of studies needed	Priority of studies within areas						
	Big Game range		Livestock range				
	Winter range areas	Summer range areas	Open high elevation range	Permanent forest range	Transitory forest range	Mountain meadows	Open low elevation range
(Priorities by areas)	A_1	D	A_2	B	C_1	C_2	C_3
ECOLOGICAL STUDIES							
Synecology of seral and climax vegetation	1	1	1	1	1		
Autecology of individual species (phenology, reproduction)	1		1	3		2	3
Indicators of range condition and trend	3		1	1		1	1
Effects of grazing upon forage species	1		1	1		1	1
Effects of grazing upon tree production	3			2	2		
Effect of grazing upon watersheds and soil stability	2	1	1				
Effect of rodents upon vegetation						4	
Interrelationship between species of grazing animals	4	2					
MANAGEMENT OBJECTIVES							
Land use determination: economic relationships between livestock, timber, big game, water	2		4	3	2		
Feasi[illegible]							2
MANAGEMENT PRACTICES 1/ AND TECHNIQUES							
Practices for maintenance of range in desireble condition	2		2	2		2	2
Practices for range rehabilitation	2		2	3		2	1
Management compatible with other land uses	2		3	3	1		
Management of seeded areas	4					4	4
Development of practical management guides	3		2	3	3	3	3
Methods for governing animal distribution	4		4				
Direct methods of plant control	4			4			3
Species and techniques for artificial revegetation	4		2	4	4		4
Intensive cultural methods for range improvement; fertilizing, renovating, trenching, etc.			3			3	
Silvicultural practices beneficial to forage growth	3			4	3		
Criteria for usable and nonusable areas			3		4		

1/ Largely management problems requiring research answers from ecological studies.

Studies needed in each major problem area along with relative priorities are also shown in table 7. Indicated priorities for studies within each major area were determined largely by a logical approach to solution of overall management problems.

The greatest research problem on Inland Empire range lands is the lack of an adequate ecological understanding of the various range types. Achieving full use of our grazing resource and development of intelligent management practices demands a great deal of fundamental knowledge of vegetation structure, successional patterns, and the effects of grazing upon community structure and plant succession. This basic information is very sketchy on most areas, if not lacking entirely. Therefore synecological studies and studies of grazing effects are given high priority under all types.

Of major importance also is the determination of indicators of range condition and trend. Such indicators are a vital range management tool; their development is directly allied with synecological studies and should receive high study priority.

PROJECT PROGRAM

A research program for the Inland Empire Research Center range project must necessarily exclude certain fields of study. The Forest Service lacks authority for research on direct methods of plant control, aside from burning, and on developing species and methods of artificial revegetation or fertilization on livestock range. Both plant control and reseeding are important problems in this area and require attention. In addition, certain land use and economic studies are beyond the scope of range personnel alone and demand the joint talents of economists, forest, range, watershed, and wildlife technicians.

Restrictions in personnel and funds necessitate a careful direction of effort where it will do the greatest good. Duplication of work being done by other agencies must be avoided.

Outlined below are first and second priority studies listed for the high priority problem areas. No attempt has been made to outline all study needs listed in table 7, rather only those considered approachable in the foreseeable future. The suggested order of study initiation in each area is indicated by numeral and letter designation.

(A_1) Big Game Winter Range

(1a) Ecological description of the Inland Empire Seral shrub complex

Objective: (a) Provide a vegetal description of the seral shrub complexes that occur in forest climax zones of the Inland Empire; (b) attempt to relate with stages in succession to the climax forest type, with different intensities and composition of tree overstory, and with past treatment. Special attention should be given to big game winter range areas, but study will have application to livestock transitory forest range as well.

Procedure: Describe vegetatively a large number of seral stage shrub plots in each of the following major forest-climax zones: cedar-hemlock, Douglas-fir, ponderosa pine. Group by age of stand, known history of cutting and/or burning, and density of overstory, and attempt correlation with each of the above.

(1b) Forage values and effects of utilization upon primary browse species.

Objectives: Determine the forage value of big game animals of common shrub species on winter range areas and the effects of degree of utilization upon same. Develop browse utilization standards. Information upon utilization effects applicable also to livestock forest range.

Procedure: By careful scrutiny of literature, records of State Fish and Game Departments, and supplemental observa-

tions, arrive at palatability ratings for shrubs common to winter range areas. Through intensive field observation of degree of utilization and effects arrive at proper utilization standards.

(1c) Phenology and reproduction of primary shrubs on winter range areas.

Objective: Determine the phenology and reproduction methods of primary browse species on big game winter range areas. Information obtained equally applicable to livestock forest range.

Procedure: Conduct yearly observations on plant development of primary browse species. In conjunction with above, make observations on occurrence of vegetative and seminal reproduction.

(2a) Methods for rehabilitating key winter range browse types.

Objective: Determine methods of returning to available production browse species that have grown beyond the reach of game animals.

Procedure: Test burning, cutting, and spraying at various seasons as methods of inducing sprouting of browse species. Attempt to enlist cooperation from State Departments of Fish and Game and from National Forest Administration in all rehabilitation studies.

(2b) Damage to timber and watershed values on big game wintering areas.

Objective: Determine the extent and severity of injury to timber reproduction and watershed values by big game concentrations on winter ranges.

Procedure: Conduct a general reconnaissance of wintering areas to determine the above.

(A_2) Open High Elevation Livestock Range

(1a) Ecological description of high elevation balds and parks

Objective: To obtain a better understanding of vegetal composition and distribution in subalpine grass and forb openings.

Procedure: Sample the vegetation and soil on a large number of balds and parks in an attempt to arrive at a vegetal classification and description of climax types.

(1b) Effect of grazing upon soil stability

Objective: Determine the influence of degree and period of grazing use upon soil stability of various high elevation range areas.

Procedure: Can be approached in several ways: by determining suitability of criteria developed in other areas (Pickford and Reid, 1942; Ellison et al, 1951); through formal grazing trials involving various degrees and periods of use; by a survey of current grazing practices and relating history with present condition; by small plot studies of artificial ground cover removal and trampling combined with infiltrometer trials.

(1c) Effect of grazing upon forage composition and production

Objective: Determine the influence of degree and period of grazing use upon forage production of various high elevation range areas.

Procedure: A companion study of (1b) above; information can be obtained from same studies but major emphasis on vegetation rather than on soil stability.

(1d) Phenology and related autecological studies of primary herbaceous species

Objective: Determine plant development, yield variations, and reproductive habits of major grasses and herbs on high elevation openings.

Procedure: Make yearly phenological and growth observations and attempt to relate with weather variations. Make incidental observations on amount and regularity of seeding and other methods of reproduction.

(1e) Indicators of range condition and trend

Objective: Determine field indicators for vegetation and soil condition and trend on high elevation range areas for administrative use.

Procedure: Utilize information obtained from the four above studies, 1a, 1b, 1c, and 1d. Test applicability of indicators developed for similar range in other areas (notably Pickford and Reid, 1942, and Ellison et al., 1951).

(2a) Grazing and cultural practices for soil stabilization on eroding areas.

Objective: Develop methods for halting erosion on high elevation ranges.

Procedure: Test effect of non-use and restricted grazing use in restoration of lightly eroding areas. Test various seeded species and trenching techniques for soil stabilization on badly eroding areas.

(2b) Grazing management compatible with watershed and forage maintenance

Objective: Determine suitable management practices, both intensities and periods of use, for maintenance of high elevation ranges. Provide management guides for administrative use.

Procedure: Utilize foregoing studies to develop tentative proper management practices.

(B) Livestock Permanent Forest Range

(1a) Ecological description of permanent forest range types

Objective: Obtain a better understanding of composition and distribution of understory vegetation primarily in the ponderosa pine zone.

Procedure: Using Daubenmire's classification (Daubenmire, 1952) as a beginning point, sample vegetation and soils on a large number of ponderosa pine sites to arrive at a classification of climax and seral types. Part of the information obtained in study (1a) under Big Game Winter Range will have application here.

(1b) Effect of grazing upon forage composition and production

Objective: Determine the influence of degree and period of use upon forage production in the ponderosa pine zone.

Procedure: Determine applicability of findings in similar areas (Pickford and Reid, 1948; Harris, 1954). Survey current grazing practices and determine effect upon vegetation and soil.

(1c) Indicators of range condition and trend.

Objective: Determine field indicators for vegetation and soil condition and trend in the ponderosa pine zone for administrative use.

Procedure: Utilize information obtained from the above two studies along with information from other areas to develop tentative guides. Determine suitability under field conditions.

(2a) Effect of grazing upon tree production.

Objective: Determine the influence of grazing use upon reproduction and growth of tree species in the ponderosa pine zone.

Procedure: Study grazed ponderosa pine sites under different conditions and intensities of use to determine effect upon tree reproduction. With assistance of timber management research, establish a series of tree growth plots on areas subject to different grazing pressures. Determine effect of grazing upon reduction in fire hazard.

(2b) Proper forage level for management purposes

Objective: Determine the level in vegetal succession best suited for grazing management purposes in the ponderosa pine zone--toward what forage level should management practices be directed on non-depleted areas and on areas badly depleted of the original plant cover.

Procedure: Study sustained productivity of areas in various vegetal conditions. Determine the obtainable level of usable

production on areas that at present are in badly depleted range condition by studying formerly depleted areas that have upward trends.

(2c) Grazing management practices compatible with timber production and forage maintenance.

Objective: Determine suitable grazing management practices for maintenance of forage and timber production in the ponderosa pine zone.

Procedure: Utilize foregoing studies and work done in other areas to develop tentative management practices. Establish a series of pasture studies to test grazing systems and intensities.

Schedule of Studies

The current range project staff consists of one permanent full-time technician. It is reasonable to suppose that at least one and possibly two temporary summer assistants will be available each year. The schedule of studies in table 8 is based upon this minimum manpower requirement and current fund limitation. Checked columns indicate the year when specific studies should be started and in progress. This schedule is flexible and its adherence dependent upon difficulties encountered, priority changes, and expediency. If additional personnel become available the entire schedule can be accelerated.

Work will be fairly restricted until the summer of 1959; the project's one full-time man will not be available during the 1957-58 and 1958-59 school years.

Table 8.--Suggested schedule of study during the next 10-year period.

Priority	Studies	1957 to 1962					1962 to 1967
		1957	1958	1959	1960	1961	
A_1	BIG GAME WINTER RANGE						
1a	Ecological description of seral shrub complex	x	x	x	x		
1b	Forage values and utilization effects on primary browse			x	x	x	
1c	Phenology and reproduction of primary shrubs				x	x	x
1d	Rehabilitation methods for key browse areas					x	x
2a	Damage to timber and watershed values						x
A_2	OPEN HIGH ELEVATION LIVESTOCK RANGE						
1a	Ecological description of balds and parks				x	x	x
1b	Effects of grazing upon soil stability					x	x
1c	Effects of grazing upon vegetation					x	x
1d	Phenology and related ecological studies						x
1e	Indicators of range condition and trend						x
2a	Grazing and cultural practices for soil stabilization						x
2b	Management compatible with watershed and forage maintenance						x
B	LIVESTOCK PERMANENT FOREST RANGE						
1a	Ecological description of permanent range type			x	x		
1b	Effect of grazing upon forage						x
1c	Indicators of range condition and trend						x

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BIBLIOGRAPHY

Adams, Lowell

1949. The effects of deer on coniferous reproduction in northwestern Montana. Jour. Forestry 47(11): 909-913.

1951. White-tailed deer browsing on ponderosa pine plantations. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 89.

1951. White-tailed deer browsing on natural conifer seedlings. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 105, 3 pp.

Anderson, William E.

1952. Grazing management of bunchgrass type forage. Northwest Sci. 26(1): 32-36.

Bailey, V.

1932. The northwestern white-tail deer. Biol. Soc. Wash. Proc. 45: 43-44.

Beattie, R. K.

1913. Plants used for food by sheep on Mica Mountain summer range. Wash. Agr. Expt. Sta. Bul. 113, 21 pp.

Buechner, Helmut K.

1952. Winter range utilization by elk and mule deer in southeastern Washington, Jour. Range Mangt. 5(2). Mar.

Cliff, Edward P.

1939. Relations between elk and mule deer in the Blue Mountains of Oregon. Trans. of Fourth North. Amer. Wildlife Conf. 560-569.

Cooper, C. S. and W. A. Sawyer.

1955. Fertilization of mountain meadows in eastern Oregon. Jour. Range Mangt. 8(1). Jan.

Cotton, J. S.

1904. Forage problems of eastern and central Washington Thesis, State College of Wash., 74 pp.

Crouch, W. E.

1942. Pocket gopher control. U. S. Dept. Int., Fish & Wildlife Serv. Cons. Bull. 23.

Daubenmire, Rexford F.

1940. Plant succession due to overgrazing in the Agropyron bunchgrass prairie of southeastern Washington. Ecol. 21(1): 55-64. Jan.

1942. An ecological study of the vegetation of southeastern Washington and adjacent Idaho. Ecol. Monog. 12:53-79. Jan.

1943. Vegetational zonation in the Rocky Mountains. Bot. Rev. 9: 325-393

1946. The life zone problem in the northern Intermountain Region. Northwest Sci. 20(2): 28-38. May.

1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. Ecol. Monog. 22: 301-330.

1955. The use of vegetation to indicate grazing potentials of forest land. 1955 Proc. of Soc. of Amer. Foresters.

1956. Climate as a determinant of vegetation distribution in eastern Washington and northern Idaho. Ecol. Monog. 26(2): 131-154. April.

Daubenmire, R. F. and W. E. Colwell.

1942. Some edaphic changes due to overgrazing in the Agropyron-poa prairie of southeastern Washington. Ecol. 23(1): 32-40.

Ellison, Lincoln, et al.

1951. Indicators of condition and trend on high range watersheds of the Intermountain Region. U. S. Dept. of Agr., Agr. Handb. No. 19.

Ensminger, M. E., et al.

1944. Grass and grass-alfalfa mixtures for beef production in eastern Washington. Wash. Agr. Expt. Sta. Bul. 444, 24 pp.

Evanko, A. B.

1952. Will beetles lick goatweed? Wash. Farmer 50(12): 16, 17, 20, June.

1952. Promising forage species and seasons for reseeding northeastern Washington scablands. North. Rocky Mountain Forest and Rge. Expt. Sta. Res. Note 106.

1953. A test of borax control of goatweed. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 134, 5 pp.

1953. Performance of several forage species on newly burned lodgepole pine sites. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 133.

1953. Forage species and planting season for reseeding cleared and abandoned ponderosa pine areas in northeastern Washington. North. Rocky Mountain Forest and Range Expt. Sta. Res. Note 119.

1954. Reseeding the range. Wash. Farmer 79(3): 5.

1954. Forage species for reseeding northeastern Washington range lands. Northwest Sci. 28(2): 70-76.

1954. State cattleman "Dutch" Bremner gets help through Curlew District. Wash. State Conserv. Dist. News 3(1): 7.

1955. Early spring grazing values of four seeded species on abandoned cropland in northeast Washington. Intermountain Forest and Range Expt. Sta. Res. Note 18.

1955. Species adaptability and seeding season for increased forage production in northeast Washington. Intermountain Forest and Range Expt. Sta. Paper 37.

Fenneman, N. M.

1931. Physiography of the western United States. McGraw-Hill Book Co., N. Y.

Friedrich, C. Allen.

1945. Seeding crested wheatgrass on cheatgrass land. North. Rocky Mountain Forest & Range Expt. Sta. Res. Note 38, March.

1947. A guide to range reseeding on and near the national forests of Montana. North. Rocky Mountain Forest & Range Expt. Sta. Paper 7, 38 pp. Oct.

1947. Seeding grass by airplane on western Montana's burned-over timberlands. North. Rocky Mountain Forest & Range Expt. Sta. Res. Note 52, 5 pp. June.

Garrison, George A.

1953. Effect of clipping on some range shrubs. Jour. Range Mangt. 6(5). Sept.

Garrison, G. A. and R. S. Rummell.

1950. First-year effects of logging on forage production. Pacific Northwest Forest & Range Expt. Sta. Res. Note 62, 5 pp. Feb.

Gilbert, C. L.

1948. Range condition: a classification of the bunchgrass forage type in the South Palouse Soil Conservation District. U. S. Dept. Agric., S.C.S., Pacific Coast Region. July.

Gjertson, J. O.

1949. Practical guides for seeding grass on skid roads, trails, and landings, following logging on east side forests of Washington and Oregon. Pacific Northwest Forest & Range Expt. Sta. Res. Note 49.

Hafenrichter, A. L., L. A. Mullen, and R. L. Brown

1949. Grasses and legumes for soil conservation in the Pacific Northwest. U. S. Dept. Agric. Misc. Pub. 678. 56 pp. Dec.

Hafenrichter, A. L.

1949. Back to grass. Washington Farmer 74(5): 3, 24. March.

Hanson, R. W.

1951. Condition classes on mountain range in southwestern Alberta. Jour. Range Mangt. 4(3): May.

Harris, G. A.

1950. Brush problem on Ferry County grazing lands. (Abs) Northwest Sci. 24: 33. Feb.

———

1951. St. Johnswort on western ranges. Northern Rocky Mountain Forest & Range Expt. Sta. Paper 26.

Harris, Robert W.

1954. Fluctuations in forage utilization of ponderosa pine ranges in eastern Oregon. Jour. Range Mangt. 7(6). Nov.

Heady, Harold F.

1950. Studies on bluebunch wheatgrass in Montana and height-weight relationships of certain range grasses. Ecol. Monog. 20: 55-81. Jan.

Huberman, M. A.

1935. The role of western white pine in forest succession in northern Idaho. Ecol. 16(2): 137-151.

Humphrey, R. R.

1945. Range condition: a classification of the Palouse grass type. U. S. Dept. Agric., Soil Conserv. Serv. Pacific Coast Region. May.

Hutchison, S. Blair and R. K. Winters

1942. Northern Idaho forest resources and industries. U. S. Dept. Agric. Misc. Pub. 508, 75 pp.

Ingram, D. C.

1931. Vegetative changes and grazing use on Douglas-fir cutover land. Jour. Agric. Res. 43: 387-417.

Kemp, Paul D. and H. J. Pissot.

1949. Forest Resources of northeast Washington. Northern Rocky Mountain Forest and Range Expt. Sta., Sta. Paper 21.

Lammi, J. O.

1955. Statistics on western wildland resources. Intermountain Forest and Range Expt. Sta., Res. Paper 31 (Rev.)

Larsen, J. A.

1923. Associations of trees, shrubs and other vegetation in northern Idaho forests. Ecol. 4: 63-67.

———

1929. Fires and forest succession in the Bitterroot Mountains of northern Idaho. Ecol. 10(1): 67-76.

———

1930. Forest types of the northern Rocky Mountains and their climatic controls. Ecol. 11(4): 631-672.

_____

1940. Site factor variations and responses in temporary forest types in northern Idaho. Ecol. Monog. 10: 1-54.

Lommasson, T.

1947. The trend of grazing capacity on burned timbered range on the Colville National Forest, Washington, 1930-1946. U. S. Forest Serv., R-1. Developments in Range Mangt. #5.

_____, and C. Jensen

1943. Determining utilization of range grasses by height-weight tables. Jour. Forestry 41: 589-593.

McCall, Ralph

1933. Seasonal variation in composition and digestibility of certain species of range bunchgrass. Amer. Soc. Anim. Prod. Proc. 1932: 95-100.

McLaughlin, W. T. and A. J. Geiger.

1948. Range condition: a classification of the yellow-pine bunchgrass range in the South Ferry Soil Conservation District. U. S. Dept. Agric., Soil Conser. Serv. Pacific Coast Reg. Sept.

_____ and Carl Sundquist

1948. Range condition: a classification of the yellow-pine bunchgrass range in the Kettle-Stevens Soil Conservation District. U. S. Dept. Agric., Soil Conser. Serv., Pacific Coast Reg. Sept.

Marsh, Vernon and R. R. Humphrey.

1946. Range condition: a classification of the scabland bunchgrass forage type in the Palouse-Rocklake Soil Conserv. District. U. S. Dept. Agric., Soil Conser. Serv., Pacific Coast Reg. Apr.

Michel, Glenn E.

1951. Status of browse on ranges of eastern Oregon and eastern Washington. Jour. Range Mangt. 4(4). July

Moore, A. W. and E. H. Reid

1951. The Dalles pocket gopher and its influence on forage production of Oregon mountain meadows. U. S. Dept. of Agric. Cir. 884. Aug.

Moreland, Raleigh

1955. New trends in game management. Paper presented at program of Pacific N.W.Sec., Amer. Soc. of Range Mgt., Yakima, Wash., Nov. 28

Neils, George, et al.

1956. Management of white-tailed deer and ponderosa pine. Jour. Forestry 54(4):238-242.

Nelson, Howard S.

1956. Phenology of goatweed (Hypericum perforatum) in relation to the behavior of goatweed beetles (Chrysolina gemellata and C. hyperici) in western Montana. Jour. Range Mgt. 9(1)27.

Ninman, H. J. and W. C. Thompson

1927. Effect of pasturage on white pine reproduction and on timber quality. Jour. Forestry 25:549-554.

Noxious Weed Control Task Force

1952. Noxious weeds in the Columbia Basin. Land Subcommittee Columbia Basin Inter-Agency Committee. Oct.

Parcell, Jack

1938. The elk problem in the Selway. Univ. Idaho Bul. 22: 23-25.

Pengally, W. Leslie

1953. Completion report for Coeur d'Alene deer management study. State of Idaho Dept. Fish and Game Fed. Aid in Wildlife Restoration.

Peterson, Roald A.

1953. Forage plants in a Montana high altitude nursery. Jour. Range Mangt. 6(4). July.

Pickford, G. D. and E. H. Reid

1942. Basis for judging sub-alpine grassland ranges of Oregon and Washington. U. S. Dept. of Agric. Cir. 655.

———

1948. Forage utilization of summer cattle ranges in eastern Oregon. U. S. Dept. of Agric. Cir. 796. Sept.

Pickford, G. D. and E. R. Jackman

1944. Reseeding eastern Oregon summer ranges. Ore. State College Agric. Expt. Sta. Cir. 159, 48 pp.

Pissot, Henry J.

1953. Forest resources of north Idaho. Northern Rocky Mountain Forest & Range Expt. Sta. Paper 35. Dec.

Pringle, W. L.

1952. The ecology and control of St. Johnswort in Idaho. M. S. Thesis. Univ. of Idaho, Moscow, Idaho.

Reid, E. H. and G. D. Pickford

1946. Judging mountain meadow range condition in eastern Oregon and eastern Washington. U. S. Dept. Agric. Cir. 748.

Royall, Willis C., Jr.

1954. Wildlife values with special reference to Idaho wildlife as a recreational resource. M. A. Thesis, Cornell Univ., Ithaca, N. Y.

Rummel, R. S.

1951. Some effects of livestock grazing on ponderosa pine forest and range in central Washington. Ecol. 32(4): 594-607. Oct.

Schwendiman, John L.

1954. New and better grasses. Wash. Farmer. Sept., pp. 20-21.

Sharp, Lee A. and E. W. Tisdale

1952. Medusa-head problem on some Idaho ranges. Univ. Ida. Forest, Wildlife & Range Expt. Sta. Res. Note 3, 9 pp.

Shaw, Wesley M.

1954. Job completion reports for Idaho game population census and range study W85-R-4, State of Ida.. Fish and Game Dept., Wildlife Restoration Division. June 1, 1952 - June 30, 1953.

Short, L.R.

1943. Reseeding to increase the yield of Montana range lands. U. S. Dept. Agric. Farmer's Bul. 1924.

Smith, G. A.

1928. Game conditions in the National forests of Montana and northern Idaho. Big Horn 5(2): 4-5.

Smith, G. A.

1932. Game management in the Inland Empire. Forestry Kaimin. 14-17.

Sparhawk, W. M.

1918. Effect of grazing upon western yellow pine reproduction in central Idaho. U. S. Dept. Agric. Bul. 738, 31 pp.

Spencer, Wesley R.

1947. Range condition: a classification of the conifer-bunchgrass range in the Davenport-Reardon Soil Conservation District. U. S. Dept. Agric., Soil Conser. Serv., Pacific Coast Region. May.

Spencer, W. R.

1947. Range condition: a classification of the channeled range lands in southwest Spokane Soil Conservation District. U. S. Dept. Agric., Soil Conser. Serv. Pacific Coast Reg. May.

Tisdale, E. W., W. Pringle, and M. Hironaka

1953. St. Johnswort on Idaho range lands. A preliminary report. Univ. Ida. Forest Wildlife & Range Expt. Sta. Res. Note 6, 9 pp.

U. S. Dept. Commerce. U. S. Census of Agriculture; Washington & Idaho, 1925, 1935, 1945, 1950, 1954.

U. S. Dept. Interior.

1956. National survey of fishing and hunting, 1955. U.S.Fish & Wildlife Serv. Cir. 44.

Wallace, Robert F.

1952. Economic aspects of wildlife resources in the state of Washington. State College of Wash., Econ. and Business Studies Bul. 19.

Weaver, J. E.

1917. A study of the vegetation of southeastern Washington and adjacent Idaho. Nebr. Univ. Studies 17, No. 1, 131 pp.

Weaver, Harold

1951. Observed effects of prescribed burning on perennial grasses in the ponderosa pine forests. Jour. of Forestry 49(4): 267-271.

Wiksten, Ake

1955. Chemical brush control experiments, 1951-1955. Weyerhaeuser Timber Co. Forestry Res. Notes. Prog. Report. Oct.

Woolfolk, E. J.

1953. Some observations on a white-tail deer winter range in Idaho. North. Rocky Mountain Forest & Range Expt. Sta. Res. Note 116, 4 pp.

_____ and Grant Harris

1951. Forage species and seasons for reseeding foothill range lands in northeastern Washington. North. Rocky Mountain Forest & Range Expt. Sta. Note 97.

Young, V. A.

1938. The carrying capacity of big game ranges. Jour. Wildlife Mangt. 2(3): 131-134.

1943. Changes in vegetation and soil of the Palouse prairie caused by overgrazing. Jour. Forestry 41(11): 834-838.

Young, V. A. et al.

1942. The influence of sheep grazing on coniferous reproduction and forage on cut-over western white pine areas in north Idaho. Univ. of Idaho Bul. 36, 46 pp.

Young, Vernon A. and W. L. Robinet

1939. A study of the range habits of elk on the Selway game preserve. Univ. of Idaho Sch. of Forestry Bul. 9, Dec.